countdown checklist must include the preflight tests of a flight safety system required in subpart D of part 417 of this chapter and must contain, but need not be limited to, the following:

(i) Identification of operations and specific actions completed and verifications performed that there are no constraints to flight and that all launch safety rules and launch commit criteria are satisfied;

(ii) Time of each event;

(iii) Identification of personnel responsible for each operation or specific action, including reporting to the launch conductor;

(iv) Identification of communication channel to be used for reporting each event;

(v) Identification of communication and event reporting protocols;

(vi) Polling of personnel who oversee all safety critical systems and operations to verify their readiness to proceed with the launch, and

(vii) Provisions for recording the status of countdown events.

(m) *Launch abort or delay recovery and recycle plan.* An applicant's safety review document must contain a plan for recovering from a launch abort or launch delay that results during a launch countdown and recycling for the next launch attempt following procedures that provide for public safety. The plan must:

(1) Contain, or incorporate by reference, all procedures for recovery from a launch abort or delay.

(2) Identify the conditions that must exist in order to make another launch attempt;

(3) Include a schedule depicting the flow of tasks and events in relation to when the abort or delay occurred and the new planned launch time;

(4) Identify all technical and readiness reviews scheduled to be conducted during the recovery period; and

(5) Identify the interfaces and supporting entities needed to support recovery operations.

(n) *License modification plan.* An applicant's safety review document must contain a plan that:

(1) Describes the applicant's process for identifying a proposed material change and making a request to the FAA for a launch license modification, pursuant to § 415.73, prior to implementing the change;

(2) Identifies the applicant's process for seeking a waiver from an FAA requirement under part 404 of this chapter;

(3) Describes a process for determining when a license modification is needed and the applicant's internal process for

documenting, reviewing, and internally approving a request for license modification before it is submitted to the FAA; and

(4) Identifies the applicant's internal authorizing personnel.

(o) *Flight termination system electronic piece parts program plan.* An applicant's safety review document must contain a plan that describes the applicant's program for selecting and testing electronic piece parts used in a flight termination system to ensure their reliability. This plan must demonstrate compliance with the requirements of appendix F of part 417 of this chapter and must:

(1) Describe the applicant's program for selecting piece parts for use in a flight termination system;

(2) Identify any derating, qualification, screening, lot acceptance testing, and lot destructive physical analysis to be performed for electronic piece parts;

(3) Identify personnel who conduct the piece part tests;

(4) Identify the pass/fail criteria for each test for each piece part;

(5) Identify the levels to which each piece part specification will be derated;

(6) Contain, or incorporate by reference, test procedures for each piece part.

§ 415.121 Launch schedule and points of contact.

(a) An applicant's safety review document must contain a launch schedule that identifies each test, review, rehearsal, and safety critical preflight operation to be conducted for each launch in accordance with §§ 417.115, 417.117, 417.119, and 417.121 of this chapter. The schedule must show start and stop times for each activity referenced to liftoff. A schedule must include, but need not be limited to those activities required by part 417 of this chapter.

(b) Either as part of the schedule or as an attachment, an applicant's safety review document must contain a summary of each scheduled activity that includes criteria for successful completion of the activity and that identifies a person by position who oversees the activity.

§ 415.123 Computing systems and software.

(a) An applicant's safety review document must describe all computing systems and software that perform a software safety critical function for any operation performed during launch processing or flight that could have a hazardous effect on the public. This includes any software function that, if

not performed, if performed out of sequence, or if performed incorrectly, may directly or indirectly cause a public safety hazard. An applicant shall implement such computing systems and software in accordance with § 417.123 and appendix H of part 417 of this chapter.

(b) An applicant's safety review document must list and describe all software safety critical functions involved in a proposed launch, including associated hardware and software interfaces. For each system with a software safety critical function, an applicant's safety review document must contain the following:

(1) A listing of all software safety critical functions including identification of safety critical interfaces with other systems;

(2) A description, including hardware, software, and layout, of any operator console and display;

(3) Flow charts or diagrams showing hardware data busses, hardware interfaces, software interfaces, data flow, power systems, and the functionality of each software safety critical function;

(4) Logic diagrams and software design descriptions;

(5) Listing of operator user manuals and documentation by title and date;

(6) The results of software hazard analyses as integrated into the system;

(7) Software test plan, test procedures, and test results; and

(8) Software development plan, including descriptions of the launch operator's implementation of the following:

(i) Software development process;

(ii) How the software will be partitioned;

(iii) Coding standards used;

(iv) Configuration control;

(v) How software changes will be implemented and tested;

(vi) How qualified software loads will be validated;

(vii) Policy on throughput and memory use limitations;

(viii) Software analysis;

(ix) Software testing and methods of independent verification and validation employed;

(x) Policy on the reuse of software;

(xi) Policy on the use of any commercial-off-the-shelf software; and

(xii) Operating system and language compilers to be employed.

§ 415.125 Unique safety policies and practices.

An applicant's safety review document must identify any public safety related policy and practice that is unique to the proposed launch in

accordance with § 417.127 of this chapter. An applicant's safety review document must describe how each unique safety policy or practice provides for public safety.

§ 415.127 Flight safety system design and operation data.

(a) *General.* An applicant's safety review document must contain the flight safety system data identified in this section for the launch of an orbital or guided sub-orbital launch vehicle that uses a flight safety system to protect public safety in accordance with § 417.107(a) of this chapter. Unless otherwise specified, all data required by this section that is applicable to an applicant's flight safety system must be submitted no later than 18 months before the applicant brings any launch vehicle to a proposed launch site. An applicant shall participate in a series of technical meetings with the FAA as needed to facilitate the review and approval of a flight safety system and its implementation.

(b) *Flight safety system description.* A safety review document must contain an overview design description of an applicant's flight safety system and its operation. Flight safety system and subsystems design and operational requirements are provided in part 417, subpart D and the appendices to part 417 of this chapter.

(c) *Flight safety system diagram.* An applicant's safety review document must contain a block diagram that identifies all flight safety system subsystems. The diagram must include, but is not limited to, the following subsystems defined in part 417, subpart D of this chapter: flight termination system; command control system; tracking; telemetry; communications; flight safety data processing, display, and recording system; and flight safety official console.

(d) *Subsystem design information.* An applicant's safety review document must contain all of the following data as applicable to each subsystem identified in the block diagram required by paragraph (c) of this section:

(1) *Subsystem description.* A physical description of each subsystem and its components, its operation, and interfaces with other systems or subsystems.

(2) *Subsystem diagram.* A physical and functional diagram of each subsystem, including interfaces with other systems and subsystems.

(3) *Component location.* Drawings showing the location of all subsystem components as installed on the vehicle, and at the launch site.

(4) *Electronic components.* A physical description of each subsystem electronic component, including operating parameters and functions at the system and piece-part level. An applicant shall also provide the name of the manufacturer and the model number of each component where applicable and identify whether the component is custom designed and built or off-the-shelf-equipment.

(5) *Mechanical components.* An illustrated parts breakdown of all mechanically operated components for each subsystem, including the name of the manufacturer and any model number.

(6) *Subsystem compatibility.* A demonstration of the compatibility of the onboard launch vehicle flight termination system with the command control system.

(7) *Flight termination system component storage, operating, and service life.* A listing of all flight termination system components that have a critical storage, operating, or service life and a summary of the applicant's procedures for ensuring that each component does not exceed its storage, operating, or service life before flight.

(8) *Flight termination system element siting.* For a flight termination system, a description of where each subsystem element is sited, where cables are routed, and identification of mounting attach points and access points.

(9) *Flight termination system electrical connectors and connections and wiring diagrams and schematics.* For a flight termination system, a description of all subsystem electrical connectors and connections, and any electrical isolation. The safety review document must also contain system wiring diagrams and schematics and identify the test points to be used for integrated testing and checkout.

(10) *Flight termination system batteries.* A description of each flight termination system battery and cell, the name of the battery or cell manufacturer, and any model numbers.

(11) *Controls and displays.* For a flight safety official console, a description identifying all controls, displays, and charts depicting how real time vehicle data and flight safety limits are displayed. The description shall identify the scales used for displays and charts.

(e) *System analyses.* An applicant shall perform the reliability and other system analyses for a flight termination system and command control system in accordance with § 417.329. An applicant's safety review document

must contain the results of each analysis.

(f) *Environmental design.* An applicant must determine the flight termination system maximum predicted environment levels in accordance with § 417.307(b) of this chapter and the design environments that include design margins in accordance with D417.3 of appendix D of part 417. An applicant's safety review document must contain a summary of the analyses and measurements used to derive the maximum predicted environment levels. The safety review document must contain a matrix that identifies the maximum predicted environment levels and the design environments.

(g) *Flight safety system compliance matrix.* An applicant's safety review document must contain a compliance matrix of the function, reliability, system, subsystem, and component requirements of part 417 of this chapter and its appendices. This matrix must identify each requirement and indicate compliance as follows:

(1) ''Yes'' shall be indicated if the applicant's system meets the requirement in part 417 of this chapter. The matrix shall reference documentation verifying compliance;

(2) ''Not applicable'' shall be indicated if the applicant's system design and operational environment are such that the requirement does not apply. For each such case, the applicant shall provide a clear and convincing demonstration of the non-applicability of that requirement as an attachment to the matrix; and

(3) ''Meets intent'' shall be indicated in each case where the applicant proposes to show that its system meets the intent of the requirement through some means other than those defined in part 417 of this chapter. For each such case, an applicant shall provide a clear and convincing demonstration through a technical rationale within the matrix, or as an attachment, that the proposed alternative achieves an equivalent level of safety.

(h) *Flight termination system installation procedures.* An applicant's safety review document must contain a list of the flight termination system installation procedures to be implemented in accordance with § 417.319 of this chapter and a synopsis of the procedures that demonstrates how they meet the requirements of § 417.319 of this chapter. The list must reference each procedure by title, any document number, and date.

(i) *Tracking validation procedures.* An applicant's safety review document must contain the procedures to be implemented according to § 417.121(h)

of this chapter for validating that the accuracy of the launch vehicle tracking data supplied to the flight safety official is in accordance with the flight safety system design and flight safety limits developed in accordance with part 417 of this chapter.

§ 415.129   Flight safety system test data.

(a) *General.* An applicant's safety review document must contain the flight safety system test data required by this section. Except for test reports, an applicant shall submit all required test data no later than 12 months before the applicant brings any launch vehicle to the proposed launch site. An applicant may submit test data earlier to allow greater time for addressing issues that may be identified by the FAA and avoid possible impact on the proposed launch date. The requirements in this section apply to all testing required by part 417, subpart D of this chapter and its appendices, including qualification, acceptance, age surveillance, and preflight testing of a flight safety system and its subsystems and individual components. Flight safety system testing need not be completed before the FAA issues a launch license. Prior to flight, a licensee must successfully complete all required flight safety system testing and submit the completed test reports and summaries of test results required by § 417.315(f) and § 417.325(d) of this chapter.

(b) *Testing compliance matrix.* An applicant's safety review document must contain a compliance matrix of all the flight safety system, subsystem, and component testing requirements of part 417 and appendices to part 417 of this chapter. This matrix must identify each test requirement and indicate compliance as follows:

(1) "Yes" shall be indicated if the applicant's system or component testing is performed in accordance with part 417 of this chapter. The matrix shall reference documentation verifying compliance;

(2) "Not applicable" shall be indicated if the applicant's system design and operational environment are such that the test requirement does not apply. For each such case, an applicant shall provide a clear and convincing demonstration, providing its technical rationale within the matrix or as an attachment to the matrix, that the test requirement does not apply;

(3) "Similarity" shall be indicated where the test requirement applies to a component whose design is being qualified based on its similarity to a previously qualified component that successfully passed all the required testing. For each such case, an applicant

shall provide a demonstration of similarity by performing the analysis required by appendix E of part 417 of this chapter. The results of each analysis must be contained within the matrix or as an attachment; and

(4) "Meets intent" shall be indicated in each case where the applicant proposes to show that its test program meets the intent of the requirement through some means other than those in part 417 of this chapter. For each such case, an applicant shall provide a clear and convincing demonstration through a technical rationale, within the matrix or as an attachment, that the alternative means achieves an equivalent level of safety.

(c) *Test program overview and schedule.* A safety review document must contain a summary of the applicant's flight safety system test program that identifies where the tests are to be performed and the personnel who ensure the validity of the results. A safety review document must contain a schedule for successfully completing each test before flight. The schedule must be referenced to the time of liftoff for the first proposed flight attempt.

(d) *Flight safety system test plans and procedures.* An applicant's safety review document must contain test plans that satisfy § 415.119(k) and the flight safety system testing requirements in subpart D and appendix E of part 417 of this chapter for all flight safety system testing. An applicant's safety review document must contain a list of all flight termination system test procedures and a synopsis of the procedures that demonstrates how they meet the testing requirements of part 417. The list must reference each procedure by title, any document number, and date.

(e) *Test reports.* An applicant's safety review document must contain test reports, prepared in accordance with § 417.315(f) and § 417.325(d) of this chapter, for each flight safety system test completed at the time of license application. An applicant shall submit any remaining test reports before flight in accordance with § 417.315(f) and § 417.325(d) of this chapter.

(f) *Reuse of flight termination system components.* For any flight termination system component to be used for more than one flight, an applicant's safety review document must contain a reuse qualification test, refurbishment plan, and acceptance test plan. This test plan must define the applicant's process for demonstrating that the component can function without degradation in performance when subjected to the qualification test environmental levels plus the total number of exposures to

the maximum expected environmental levels for each of the flights to be flown.

§ 415.131   Flight safety system crew data.

(a) An applicant's safety review document must identify each flight safety system crew position and the role of that crewmember during launch processing and flight of a launch vehicle.

(b) An applicant's safety review document must identify the senior flight safety official by name and demonstrate that this individual's qualifications comply with the requirements of § 417.331 of this chapter.

(c) An applicant's safety review document must describe the certification and training program for flight safety system crewmembers established to ensure compliance with § 417.105 and § 417.331 of this chapter.

9. Appendixes B and C to part 415 are added to read as follows:

Appendix B to Part 415—Safety Review Document Outline

This appendix contains the format and numbering scheme for a safety review document to be submitted as part of an application for a launch license. Administrative requirements applicable to a safety review document are provided in § 415.107. Requirements for the form and content of each part of a safety review document are provided in parts 413 and 415 of this chapter. Technical requirements related to the information contained in a safety review document are provided in part 417 of this chapter. The applicable sections of parts 413, 415, and 417 of this chapter are referenced in the outline below.

Safety Review Document

1.0 Launch Description (§ 415.109)

1.1 Purpose
1.2 Launch Schedule
1.3 Launch Site Description
1.4 Launch Vehicle Description
1.5 Payload Description
1.6 Trajectory
1.7 Staging Events
1.8 Vehicle Performance Graphs
1.9 Unguided Suborbital Rocket Design Configuration

2.0 Launch Operator Information (§ 415.111)

2.1 Launch Operator Administrative Information (§ 415.111 and § 413.7)
2.2 Launch Operator Organization (§ 415.111 and § 417.103)
2.2.1 Organization Summary
2.2.3 Organization Charts
2.2.4 Office Descriptions and Safety Functions

3.0 Launch Personnel Certification Program (§ 415.113 and § 417.105)

3.1 Program Summary
3.2 Program Implementation Document(s)
3.3 Table of Safety Critical Tasks Performed by Certified Personnel

Appendix C to Part 415—Ground Safety Analysis Report

C415.1   General

(a) This appendix provides the content and format requirements for a ground safety analysis report that must be submitted to the FAA as part of a launch license application in accordance with § 415.117. An applicant shall perform a ground safety analysis in accordance with subpart E of part 417 of this chapter and submit a ground safety analysis report in accordance with this appendix.

(b) A ground safety analysis report must contain hazard analyses that describe all hazard controls, and describe a launch operator's hardware, software, and operations so that the FAA may assess the adequacy of the hazard analysis. A launch operator shall document all hazard analyses on hazard analysis forms in accordance with C415.3(d) and submit systems and operations descriptions as a separate volume of the report.

(c) A ground safety analysis report must include a table of contents and provide definitions of any acronyms and unique terms used in the report.

(d) Instead of repeating the data, a launch operator's ground safety analysis report may reference other documents submitted to the FAA that contain the information required by this appendix.

C415.3   Ground Safety Analysis Report Chapters

(a) *Introduction.* A ground safety analysis report must include an introductory chapter that describes all administrative items such as purpose, scope, safety certification of personnel who performed any part of the analysis, and any special interest items, such as high-risk situations or potential non-compliance with any applicable FAA requirement.

(b) *Launch vehicle and operations summary.* A ground safety analysis report must include a chapter that provides general safety information about the vehicle and operations, including the payload and flight termination system. This chapter must serve as an executive summary of detailed information contained within the report.

(c) *Systems, subsystems, and operations information.* A ground safety analysis report must include a chapter that provides detailed safety information about each launch vehicle system, subsystem and operation and any associated interfaces. The data in this chapter must be in accordance with the following:

(1) *Introduction.* A launch operator's ground safety analysis report must contain an introduction to its systems, subsystems, and operations information that serves as a roadmap and checklist to ensure all applicable items are covered. All flight and ground hardware must be identified with a reference to where the items are discussed in the document. All interfacing hardware and operations must be identified with a reference to where the items are discussed in the document. The introduction must identify interfaces between systems and operations and the boundaries that describe a system or operation.

(2) *Subsystem description.* For each hardware system identified in a ground safety analysis report as falling under one of the hazardous systems listed in paragraphs (c)(3), (c)(4) and (c)(5) of this section, the report must identify each of the hardware system's subsystems. A ground safety analysis report must describe each hazardous subsystem in accordance with the following format:

(i) General description, including nomenclature, function, and a pictorial overview ;

(ii) Technical operating description, including text and figures describing how a subsystem works and any safety features and fault tolerance levels;

(iii) Safety critical parameters, including those that demonstrate implemented system safety approaches that are not evident in the technical operating description or figures, such as factors of safety for structures and pressure vessels;

(iv) Major components including any part of a subsystem that must be technically described in order to understand the subsystem hazards. For a complex subsystem such as a propulsion subsystem, a majority of the detail, including any figures shall be provided at the major component level such as tanks, engines and vents. The

presentation of figures in the report shall progress in detail from broad overviews to narrowly focused figures. Each figure must have supporting text that explains what the figure is intended to illustrate;

(v) Ground operations and interfaces including interfaces with other launch vehicle and launch site subsystems. A ground safety analysis report must identify a launch operator's hazard controls for all operations that are potentially hazardous to the public. The report must contain facility figures that illustrate where hazardous operations take place and must identify all areas where controlled access is employed as a hazard control; and

(vi) Hazard analysis summary of subsystem hazards that identifies each specific hazard and the threat to public safety. This summary must provide cross-references to the hazard analysis form required in C415.3(d) and indicate the nature of the control, such as design margin, fault tolerance, or procedure.

(3) *Flight hardware.* For each stage of a launch vehicle, a ground safety analysis report must identify all flight hardware systems using the following sectional format:

(i) Structural and mechanical systems;
(ii) Ordnance systems;
(iii) Propulsion and pressure systems;
(iv) Electrical and non-ionizing radiation systems; and
(v) Ionizing radiation sources and systems.

(4) *Ground hardware.* A ground safety analysis report must identify the launch operator's ground hardware, including launch site and ground support equipment, that contains hazardous energy or materials, or that can affect flight hardware that contains hazardous energy or materials. All ground hardware shall be identified using the following sectional format:

(i) Structural and mechanical ground support and checkout systems;
(ii) Ordnance ground support and checkout systems;
(iii) Propulsion and pressure ground support and checkout systems;
(iv) Electrical and non-ionizing radiation ground support and checkout systems;

(v) Ionizing radiation ground support and checkout systems;
(vi) Hazardous materials; and
(vii) Support and checkout systems and any other safety equipment used to monitor or control a potential hazard not otherwise addressed above.

(5) *Flight safety system.* A ground safety analysis report must describe the hazards of inadvertent actuation of the launch operator's flight safety system, potential damage to the flight safety system during ground operations, and the hazard controls to be implemented.

(6) *Hazardous materials.* A ground safety analysis report must identify any hazardous materials used in the launch operator's flight and ground systems, including the quantity and location of each. A ground safety analysis report must contain a summary of the launch operator's approach for protecting the public from toxic plumes, including the all toxic concentration thresholds used to control public exposure and a description of any related local agreements. The ground safety analysis report must describe any toxic plume model used to protect public safety and contain any algorithms implemented by the model. For a launch that involves the use of any toxic propellants, the ground safety analysis report must include the products of the launch operator's toxic release hazard analysis for launch processing in accordance with paragraph I417.7(m) of appendix I of part 417 of this chapter.

(d) *Hazard analysis.* A ground safety analysis report must include a chapter containing a hazard analysis of the launch vehicle and launch vehicle processing and interfaces. The hazard analysis must identify each hazard and all hazard controls to be implemented. A ground safety analysis report must contain the results of the launch operator's hazard analysis of each system, subsystem, and operation using a standardized format that includes all of the items listed on the example hazard analysis form provided in figure C415–1 and in accordance with the following:

(1) *Introduction.* A ground safety analysis report must contain an introduction that serves as a roadmap and checklist to the launch operator's hazard analysis forms. All flight and ground hardware must be identified with a reference to where the items are discussed in the ground safety analysis report. All interfacing hardware and operations must be similarly addressed. The introduction must explain how a launch operator has chosen to present its hazard analysis in terms of hazard identification numbers as identified in figure C415–1.

(2) *Analysis.* Each hazard may be presented on a separate form or a launch operator may consolidate hazards of a specific system, subsystem, component, or operation onto a single form. There must be at least one form for each hazardous subsystem and each hazardous subsystem operation. A launch operator must state which approach it has chosen in the introduction to the hazard analysis section. Each identified hazard control must be separately tracked.

(3) *Numbering.* Each hazard analysis form shall be numbered with the applicable system or subsystem identified. Each line item on a hazard analysis form shall be numbered, with numbers and letters provided for multiple entries against an individual line item. A line item consists of a hardware or operation description and a hazard.

(4) *Hazard analysis data.* A hazard analysis form must contain or reference all information necessary to understand the relationship of a system, subsystem, component, or operation with a hazard cause, control, and verification.

(e) *Hazard analysis supporting data.* A ground safety analysis report must include data that supports the hazard analysis. If such data does not fit onto the hazard analysis form it shall be provided in a supporting data chapter. This chapter must contain a table of contents and may reference other documents that contain supporting data.

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Figure C415-1, Example Hazard Analysis Form

System/Subsystem/Operation:

HIN* Status	Hardware or Operation	Hazard and Effects	Hazard Causes	Hazard Controls	Safety Verifications
(Hazard Item Number and status: open or closed)	(Brief description of the operation or system including identification of its boundaries.)	(Description of each associated hazard. Identification and location of the public at risk and a description of the potential adverse effects on people and property.)	(Description of each event that may result in a hazard having an adverse affect on the public.)	(Description of each system design safety devices, or operational procedure to be implemented to protect the public. If there is no public hazard associated with an operation or system, the analysis must explain the basis for that conclusion.)	(The verification status of each hazard control, whether the hazard control is "open" or "closed," and identification of drawings, reports, or procedures that verify that a control is in place.)

HIN*: A Hazard Item Number (HIN) must be used to track each hazard to closure. Each HIN must be unique to a specific hazard with no duplication of HINs for the launch program. A hazard may have more than one HIN or a series of HINs. A launch operator may assign a HIN to track the status of an individual hazard cause, control, or verification. The status of each HIN entry in a hazard analysis form must be listed as either open or closed. There must be a means to track individual open items to closure for each hazard. A line must separate each HIN entry on a hazard analysis form.

9. Revise part 417 to read as follows:

PART 417—LAUNCH SAFETY

Subpart A—General

Sec.
417.1   Scope.
417.3   Definitions.
417.5   Launch safety responsibility.
417.7   Launch site responsibility.
417.9   Safety review document and launch specific updates.
417.11   License flight readiness.
417.12–417.100   [Reserved]

Subpart B—Launch Safety Requirements

417.101   Scope.
417.103   Launch operator organization.
417.105   Launch personnel qualifications and certification.
417.107   Flight safety.
417.109   Ground safety.
417.111   Launch plans.
417.113   Launch safety rules.
417.115   Tests.
417.117   Reviews.
417.119   Rehearsals.
417.121   Safety critical preflight operations.
417.123   Computing systems and software.
417.125   Launch of an unguided suborbital rocket.

417.127   Unique safety policies and practices.
417.128–417.200   [Reserved]

Subpart C—Flight Safety Analysis

417.201   Scope.
417.203   General.
417.205   Trajectory analysis.
417.207   Malfunction turn analysis.
417.209   Debris analysis.
417.211   Flight control lines analysis.
417.213   Flight safety limits analysis.
417.215   Straight-up time analysis.
417.217   Wind analysis.
417.219   No-longer-terminate (gate) analysis.
417.221   Data loss flight time analysis.
417.223   Time delay analysis.
417.225   Flight hazard area analysis.
417.227   Debris risk analysis.
417.229   Toxic release hazard analysis.
417.231   Distant focus overpressure explosion hazard analysis.
417.233   Conjunction on launch assessment.
417.235   Analysis for launch of an unguided suborbital rocket flown with a wind weighting safety system.
417.236–417.300   [Reserved]

Subpart D—Flight Safety System

417.301   General.
417.303   Launch vehicle flight termination system functional requirements.

417.305   Flight termination system reliability.
417.307   Flight termination system environment survivability.
417.309   Command destruct system.
417.311   Inadvertent separation destruct system.
417.313   Flight termination system safing and arming.
417.315   Flight termination system testing.
417.317   Flight termination system preflight testing.
417.319   Flight termination system installation procedures.
417.321   Flight termination system monitoring.
417.323   Command control system requirements.
417.325   Command control system testing.
417.327   Support systems.
417.329   Flight safety system analysis.
417.331   Flight safety system crew roles and qualifications.
417.332–417.400   [Reserved]

Subpart E—Ground Safety

417.401   Scope.
417.403   General.
417.405   Ground safety analysis.
417.407   Hazard control implementation.
417.409   System hazard controls.
417.411   Safety clear zones for hazardous operations.

Authority: 49 U.S.C. 70101–70121.

Subpart A—General

§ 417.1   Scope.

This part prescribes the responsibilities of a launch operator conducting a licensed launch of an expendable launch vehicle and the requirements with which a licensed launch operator must comply to maintain a license and conduct a launch. The safety requirements contained in this part apply to all licensed launches of expendable launch vehicles. The administrative requirements for submitting material to the FAA contained in this part apply in total to all licensed launches from a non-federal launch site. For a licensed launch from a federal launch range where there is a federal range safety organization overseeing the safety of each licensed launch, the administrative requirements contained in this part that apply to such a launch will be identified during the licensing process in accordance with subpart C of part 415 of this chapter, but may vary depending on the FAA's current baseline assessment of the federal launch range's safety process. Requirements for preparing a license application to conduct a launch, including all related policy and safety reviews and payload determinations are contained in parts 413 and 415 of this chapter.

§ 417.3   Definitions.

For the purpose of this part,
Casualty means serious injury or death.
Command control system means the portion of a flight safety system that

includes all components needed to send a flight termination control signal to an onboard vehicle flight termination system. A command control system starts with flight termination activation switches at the flight safety official console and ends at each command-transmitting antenna. It includes all intermediate equipment, linkages, and software and any auxiliary transmitter stations that ensure a command signal will reach the onboard vehicle flight termination system from liftoff until the launch vehicle achieves orbit or can no longer reach a populated or other protected area.
Command destruct system means a portion of a flight termination system that includes all components on board a launch vehicle that receive a flight termination control signal and achieve destruction of the launch vehicle. A command destruct system includes all receiving antennas, receiver decoders, explosive initiating and transmission devices, safe and arm devices and ordnance necessary to achieving destruction of the launch vehicle upon receipt of a destruct command.
Conjunction on launch means the approach of a launch vehicle or any launch vehicle component or payload within 200 kilometers of a habitable orbiting object, either during the flight of an unguided suborbital rocket or during the ascent to orbit and first orbit of an orbital launch vehicle.
Countdown means the timed sequence of events that must take place to initiate flight of a launch vehicle.
Crossrange means the distance measured along a line whose direction is either 90 degrees clockwise (right crossrange) or counter-clockwise (left crossrange) to the projection of a launch vehicle's planned nominal velocity vector azimuth onto a horizontal plane tangent to the ellipsoidal Earth model at the launch vehicle's sub-vehicle point. The terms, right crossrange and left crossrange, may also be used to indicate direction.
Data loss flight time means the shortest elapsed thrusting time during which a launch vehicle can move from its normal trajectory to a condition where it is possible for the launch vehicle to endanger the public. Data loss flight times are used to determine when a launch vehicle's flight must be terminated if launch vehicle tracking data is no longer available to the flight safety official.
Destruct means the act of terminating the flight of a launch vehicle in a way that destroys the launch vehicle and disperses or expends all remaining propellant and renders remaining energy sources non-propulsive before

the launch vehicle or any launch vehicle component or payload impacts the Earth's surface.
Document means, when used as a verb, to create and maintain a written record.
Downrange means the distance measured along a line whose direction is parallel to the projection of a launch vehicle's planned nominal velocity vector azimuth into a horizontal plane tangent to the ellipsoidal Earth model at the launch vehicle sub-vehicle point. The term downrange may also be used to indicate direction.
Drag impact point means a launch vehicle impact point corrected for atmospheric drag.
Dwell time means the period during which a launch vehicle impact point is over a populated or other protected area. Dwell time also means the period during which an object is subjected to a test condition.
Expendable launch vehicle means a launch vehicle whose propulsive stages are flown only once.
Family performance data means the results of launch vehicle component and system tests that represent similar characteristics for a launch vehicle component or system and is data that is continuously updated as additional samples of a given component or system are tested. Family performance data is used as a baseline for comparison to the results of subsequent tests of the given component or system.
Flight control line means a boundary used to define the region over which a launch vehicle will be allowed to fly and where any debris resulting from normal flight or any launch vehicle malfunction will be allowed to impact.
Flight safety limit means criteria that ensure that a launch vehicle's debris impact dispersion does not cross over any flight control line established for the flight.
Flight safety official means the person designated by a launch operator who monitors the flight of a launch vehicle and makes a flight termination decision when a launch vehicle failure occurs and the launch vehicle violates an established flight safety limit or other flight safety criterion.
Flight safety system means the system that provides a means of control during flight for preventing a launch vehicle and any component, including any payload, from reaching any populated or other protected area in the event of a launch vehicle failure. A flight safety system includes the hardware and software used to protect the public in the event of a launch vehicle failure and the functions of any flight safety system crew. One typical U.S. flight safety

system, for example, incorporates a flight termination system, a command control system, and support systems such as tracking and telemetry.

Flight safety system crew means each of the personnel, designated by a launch operator, who operate flight safety system hardware and software. The functions of a flight safety system crew are part of the flight safety system. A flight safety system crew includes a flight safety official and the personnel who support the flight safety official during launch.

Flight termination system means all components, onboard a launch vehicle, that provide the ability to end a launch vehicle's flight in a controlled manner. A flight termination system consists of all command destruct systems, inadvertent separation destruct systems, or other systems or components that are onboard a launch vehicle and used to terminate flight.

Gate means the portion of a flight control line or other flight safety limit boundary through which a launch vehicle's tracking icon may pass without flight termination.

HTPB means hydroxy-terminated polybutadiene.

In-family means a launch vehicle component or system test result indicating that the component or system's performance conforms to the family performance data that was established by previous test results.

Inadvertent separation destruct system means an automatic destruct system that uses mechanical means to trigger the destruction of a launch vehicle stage.

Instantaneous impact point means an impact point, following thrust termination of a launch vehicle, calculated in the absence of atmospheric drag effects.

Launch area means the portion of a flight corridor defined by the flight control lines from the launch point to a point 100 nautical miles in the downrange direction.

Launch azimuth means the horizontal angular direction initially taken by a launch vehicle at liftoff, measured clockwise in degrees from true north.

Launch conductor means a person designated by a launch operator who conducts preflight launch processing, hazardous operations, systems testing, and the launch countdown. A launch conductor coordinates activities with a launch safety director and reports directly to a launch director.

Launch crew means all personnel who control the countdown and flight of a launch vehicle or who make irrevocable operational decisions that have the potential for impacting public safety. A

launch crew includes, but is not limited to, members of the flight safety system crew.

Launch director means an internal launch operator management employee who ensures public safety and who has final approval authority for launch. A launch director ensures that all public safety related issues are resolved prior to flight.

Launch processing means all preflight preparation of a launch vehicle at a launch site, including buildup of the launch vehicle, integration of the payload, and fueling.

Launch safety director means a person designated by a launch operator who oversees a launch safety organization and all activities related to ensuring public safety. A launch safety director reports directly to the launch director.

Launch wait means a relatively short period of time when launch is not permitted in order to avoid a conjunction on launch or to safely accommodate temporary intrusion into a flight hazard area. Launch waits can occur within a launch window, can delay the start of a launch window, or terminate a launch window early.

Launch window means a period of time during which the flight of a launch vehicle may be initiated.

Nominal means in reference to launch vehicle performance, trajectory, or stage impact point, a launch vehicle flight where all vehicle aerodynamic parameters are as expected, all vehicle internal and external systems perform exactly as planned, and there are no external perturbing influences other than atmospheric drag and gravity.

Non-operating environment means an environment that a launch vehicle component experiences before flight and when not otherwise being subjected to acceptance tests. Non-operating environments include, but need not be limited to, storage, transportation, and installation.

Operating environment means an environment that a launch vehicle component will experience during acceptance testing, launch countdown, and flight. Operating environments include shock, vibration, thermal cycle, acceleration, humidity, and thermal vacuum.

Operating life means, for a flight safety system component, the period of time beginning with activation of the component or installation of the component on a launch vehicle, whichever is earlier, for which the component is capable of satisfying all its performance specifications through the end of flight.

Operation hazard means a hazard derived from an unsafe condition

created by a system or operating environment or by an unsafe act.

Out-of-family means a component or system test result where the component or system's performance does not conform to the family performance data that was established by previous test results and is an indication of a potential problem with the component or system requiring further investigation and corrective action.

Passive component means a flight termination system component that does not contain active electronic piece parts such as microcircuits, transistors, and diodes. Passive components include, but need not be limited to, radio frequency antennas, radio frequency couplers, and cables and rechargeable batteries, such as nickel cadmium batteries.

PBAN means polybutadiene-acrylic acid-acrylonitrile terpolymer.

Performance specification means a statement prescribing the particulars of how a component or part is expected to perform in relation to the system that contains the component or part. A performance specification includes specific values for range of operation, input, output, or other parameters that define the component's or part's expected performance.

Populated area means an outdoor location, structure, or cluster of structures that may be occupied by people. Sections of roadways and waterways that are frequented by automobile and boat traffic are populated areas. Agricultural lands, if routinely occupied by field workers, are also populated areas.

Protected area means a populated or other area not controlled by a launch operator that is not evacuated during flight and that must, in order to protect the public, be protected from the effects of nominal and non-nominal launch vehicle flight.

Public safety means, for a particular licensed launch, the safety of people and property that are not involved in supporting the launch and includes those people and property that may be located within the boundary of a launch site, such as, visitors, individuals providing goods or services not related to launch processing or flight, and any other launch operator and its personnel.

Safety critical means essential to safe performance or operation. A safety critical system, subsystem, component, condition, event, operation, process, or item is one whose proper recognition, control, performance, or tolerance is essential to ensuring public safety. A safety critical item may create a safety hazard or provide protection from a safety hazard.

Serious injury means any injury which: (1) Requires hospitalization for more than 48 hours, commencing within seven days from the date the injury was received; (2) results in a fracture of any bone (except simple fractures of fingers, toes, or nose); (3) causes severe hemorrhages, nerve, muscle, or tendon damage; (4) involves any internal organ; or (5) involves second- or third-degree burns, or any burns affecting more than five percent of the body surface.

Service life means, for a flight termination system component, the sum total of the component's storage life and operating life.

Sigma means standard deviation.

Storage life means, for a flight termination system component, the period of time after manufacturing of the component is complete until the component is activated or installed on a launch vehicle, whichever is earlier, during which the component may be subjected to storage environments and must remain capable of satisfying all its performance specifications.

Sub-vehicle point means the location on the ellipsoidal Earth model where the normal to the ellipsoid passes through the launch vehicle's center of gravity. The term is the same as the weapon system term ''sub-missile point.''

System hazard means a hazard associated with a hardware system and that generally exist even when no operation is occurring. System hazards that may be found at a launch site include, but are not limited to, explosives and other ordnance, solid and liquid propellants, toxic and radioactive materials, asphyxiants, cryogens, and high pressure.

Tracking icon means the representation of a launch vehicle's present position displayed to a flight safety official at the flight safety official's console during real-time tracking of the launch vehicle's flight.

Uprange means the distance measured along a line that is 180 degrees to the downrange direction. The term uprange may also be used to indicate direction.

§ 417.5   Launch safety responsibility.

A launch operator shall safely conduct a licensed launch in accordance with § 415.71 of this chapter. A launch operator shall conduct the flight of a launch vehicle from any launch site in accordance with the requirements of part 415 of this chapter and this part.

§ 417.7   Launch site responsibility.

A launch operator shall ensure the safe conduct of launch processing at a launch site in the United States in accordance with the requirements of this part 417. Launch processing at a launch site outside the United States may be subject to the requirements of the governing jurisdiction. Requirements that apply to a launch site operator are contained in part 420 of this chapter. A launch operator shall coordinate and perform launch processing in accordance with any local agreements designed to ensure that the responsibilities and requirements in this part and part 420 of this chapter are met. Where there is a licensed launch site operator, a launch operator licensee shall ensure that its operations are conducted in accordance with any agreements that the launch site operator has with any federal and local authorities pursuant to part 420 of this chapter. A licensed launch operator shall coordinate with the launch site operator and provide the launch site operator any information on its activities and potential hazards necessary for the launch site operator to determine how to protect any other launch operators and persons and their property at the launch site in accordance with the launch site operator's obligations under 14 CFR 420.55. For a launch that is conducted from an exclusive use site where there is no licensed launch site operator, the launch licensee shall satisfy the requirements of this part and the public safety requirements of part 420 of this chapter.

§ 417.9   Safety review document and launch specific updates.

(a) *General.* A launch operator shall conduct each launch in accordance with a safety review document developed in accordance with part 415 of this chapter and maintained and updated for each launch in accordance with the requirements of this part. A launch operator shall submit launch specific updates required by this part and any required by the terms of the launch operator's license. A launch specific update must be submitted to the FAA to allow for review and determination prior to the associated scheduled activity. Any change to the information in a licensee's safety review document that is not identified as a launch specific update must be submitted to the FAA as a request for license modification in accordance with § 415.73 of this chapter and the license modification plan required by § 415.119(n) of this chapter. A launch operator must obtain FAA approval of any license modification before flight.

(b) *Launch specific updates.* For each launch, a launch operator's launch specific updates shall include, but need not be limited to, the following:

(1) *Launch schedule and points of contact.* A launch operator shall conduct a launch in accordance with the launch schedule submitted during the licensing process in accordance with § 415.121 of this chapter and as updated for each launch. For each launch, a launch operator shall submit an updated launch schedule and points of contact no later than six months before flight. A launch operator shall immediately submit any later change to ensure that the FAA has the most current data.

(2) *Flight safety system test schedule.* A launch operator shall test its flight safety system in accordance with the flight safety system test schedule submitted during the licensing process in accordance with § 415.129(c) of this chapter and as updated for each launch. For each launch, a launch operator shall submit an updated flight safety system test schedule and points of contact no later than six months before flight. A launch operator shall immediately submit any subsequent change to ensure that the FAA has the most current data.

(3) *Launch operator organization.* A launch operator shall submit updated organization data no later than six months prior to flight in accordance with § 417.103(a).

(4) *Launch plans.* A launch operator shall submit any changes or additions to its flight safety plan, ground safety plan, or other launch plans to the FAA no later than 15 days before the associated activity is to take place in accordance with § 417.111(b).

(5) *Six-month flight safety analysis.* A launch operator shall perform flight safety analysis for each launch and submit launch specific analysis products to the FAA no later than six months prior to the date of each planned flight in accordance with § 417.203(c)(2).

(6) *Thirty-day flight safety analysis update.* A launch operator shall submit updated flight safety analysis products for each launch no later than 30 days prior to flight in accordance with § 417.203(c)(3).

(7) *Flight termination system qualification test reports.* A launch operator shall submit all flight termination system qualification test reports to the FAA no later than six months prior to the first flight attempt in accordance with § 417.315(f)(1).

(8) *Flight termination system acceptance and age surveillance test report summaries.* A launch operator

shall submit a summary of the results of each flight termination system acceptance and age surveillance test no later than 30 days prior to the first flight attempt for each launch in accordance with § 417.315(f)(2).

(9) *Command control system acceptance test reports.* A launch operator shall submit all command control system acceptance test reports to the FAA no later than 30 days prior to the first flight attempt in accordance with § 417.325(d).

(10) *Ground safety plan.* A launch operator shall keep current its ground safety plan for each launch and shall submit any change to the FAA no later than 15 days before the change is implemented in accordance with § 417.403(c).

§ 417.11 License flight readiness.

(a) For each launch, a launch operator shall verify that the launch is conducted in accordance with the terms and conditions of the launch license and the requirements of this part.

(b) For each launch, a launch operator shall verify that all license related information submitted to the FAA in accordance with the terms and conditions of the launch license and the requirements of this part reflects the current status of each of the licensee's systems and processes as they are implemented for that launch.

(c) For each launch, a launch operator shall submit a signed written statement in accordance with the signature requirements in § 413.7 of this chapter, that the launch is being conducted in accordance with the terms and conditions of the launch license and FAA regulations. The launch operator must state in writing that all required license related information was submitted to the FAA and that the information reflects the current status of the licensee's systems and processes as they are being implemented for that launch. The launch operator shall submit this written statement to the FAA no later than ten days before the first planned flight attempt for each launch.

(d) The FAA will evaluate each planned launch for compliance with the terms and conditions of the launch license and FAA regulations. The FAA will notify a launch operator of any licensing issue and coordinate with the launch operator to resolve any issue prior to flight. A launch operator shall not proceed with the flight of a launch vehicle if there is any licensing issue that has not been resolved.

(e) For each licensed launch, the launch operator shall provide the FAA with a console for monitoring the

progress of the countdown and communication on all channels of the countdown communications network. The launch operator shall ensure that the FAA is polled over the communications network during the countdown to verify that the FAA has identified no issues related to the launch operator's license.

§§ 417.12–417.100 [Reserved]

Subpart B—Launch Safety Requirements

§ 417.101 Scope.

This subpart contains requirements that apply to the launch of orbital and suborbital expendable launch vehicles. This subpart provides an overview of the public safety issues that a launch operator's launch safety program must address. For each public safety issue, this subpart provides either the applicable requirements in their entirety or an overview of the requirements and references other subparts, sections, or appendices that contain additional requirements.

§ 417.103 Launch operator organization.

(a) For each launch, a launch operator shall establish and maintain an organization that ensures public safety and that the requirements of this part are satisfied. Each launch management position and organizational element must have documented roles, duties, and authorities. Any change in a licensee's organization from the data that was provided during the licensing process must provide for an equivalent level of safety. For each launch a launch operator shall submit updated organization data no later than six months prior to flight. A launch operator shall immediately submit any later change to ensure that the FAA has the most current data as the date of the planned flight approaches.

(b) A launch operator's organization must include, but need not be limited to, the following launch management positions and organizational elements:

(1) *Launch director.* A launch operator shall designate as launch director the launch operator employee who has the launch operator's final approval authority for launch. The launch director shall ensure public safety and shall ensure that all of the launch safety director's concerns are resolved prior to flight.

(2) *Launch safety director.* A launch operator shall designate an official who oversees its launch safety organization and all activities related to ensuring public safety. A launch safety director shall report directly to the launch director.

(3) *Launch conductor.* A launch operator shall designate an official who conducts preflight launch processing, hazardous operations, systems testing, and countdown. A launch conductor shall coordinate activities with the launch safety director and shall report directly to the launch director.

(4) *Flight safety organization.* For a launch using a flight safety system, a launch operator shall establish an organization that performs and documents the flight safety analysis required by subpart C of this part and ensures compliance with the flight safety system requirements of subpart D, including the flight safety system crew requirements of § 417.331. For launch of a unguided suborbital rocket that uses a wind weighting safety system, a launch operator shall establish an organization that ensures compliance with the flight safety analysis required by subpart C of this part and the flight safety and personnel requirements of § 417.125(g).

(5) *Ground safety organization.* A launch operator shall establish an organization that ensures compliance with the ground safety analysis and program requirements of subpart E of this part.

(6) Launch processing. A launch operator shall establish organizational elements that implement launch plans in accordance with § 417.111 and accomplish the tests, reviews, rehearsals, and safety critical operations required by §§ 417.115, 417.117, 417.119, and 417.121.

§ 417.105 Launch personnel qualifications and certification.

(a) *General.* A launch operator shall establish and document the qualifications, including education, experience, and training, for each launch personnel position that oversees, performs, or supports a hazardous operation with the potential to adversely affect public safety or who uses or maintains safety critical systems or equipment that protect the public. A launch operator shall implement a certification program that ensures that personnel possess the qualifications for their assigned tasks. These personnel positions include, but need not be limited to, those listed in § 417.103(b). Flight safety system crew qualification requirements for a launch using a flight safety system are provided in § 417.331.

(b) *Personnel certification program.* A launch operator's personnel certification program must include, but need not be limited to, the following:

(1) For each hazardous operation or safety critical system or equipment, a launch operator shall designate an individual by position who reviews

personnel qualifications and issues certifications for demonstrated knowledge, skill and competence to perform safety related tasks.

(2) Re-certification of personnel shall be performed annually or for each launch if the time period between each launch is greater than one year. Re-certification procedures shall be established and followed by the certifying organization, and shall include, but need not be limited to, a review of an individual's work record and current job knowledge and skill requirements, determination of the need for additional training, and completion of additional training where needed.

(3) A launch operator shall revoke individual certifications for negligence or failure to satisfy certification or re-certification requirements.

(4) A launch operator shall maintain qualification and certification records for each individual performing safety-related functions.

§ 417.107   Flight safety.

(a) *Flight safety system.* For each launch, a launch operator shall employ a flight safety system that provides a means of control during flight for preventing a launch vehicle and any component, including any payload, from reaching any populated or other protected area in the event of a launch vehicle failure. For each launch vehicle, vehicle component, and payload, a launch operator shall employ a flight safety system that satisfies all the functional, design, and test requirements of subpart D of this part unless one of the following exceptions applies:

(1) A launch operator need not employ a flight safety system if the launch vehicle, vehicle component, or payload does not have sufficient energy at any time during flight to reach any protected area.

(2) A launch operator need not employ a flight safety system if the launch vehicle is a suborbital rocket that does not employ a guidance system for directional control and the launch operator demonstrates that the launch will be conducted safely using a wind weighting safety system in accordance with § 417.125.

(3) A launch operator's flight safety system must satisfy all the functional, design, and test requirements of subpart D of this part unless the FAA approves the use of an alternate flight safety system through the licensing process. The FAA will approve the use of an alternate flight safety system that does not satisfy all of subpart D of this part if a launch operator demonstrates clearly and convincingly that the

proposed launch achieves a level of safety that is equivalent to satisfying all the requirements of this subpart and subpart D of this part. The following apply when a launch operator seeks FAA approval for such a launch:

(i) The launch operator shall demonstrate that the launch presents significantly less public risk than the risk criteria required by paragraph (b) of this section. The reduced level of public risk must correspond to the reduced capabilities of the proposed alternate flight safety system. To achieve the reduced level of public risk, the launch must take place from a remote launch site with an absence of population and any overflight of a populated area must take place only in the later stages of flight.

(ii) The launch operator shall demonstrate the reliability of the proposed alternate flight safety system to perform its intended functions. An alternate flight safety system that does not possess all the functional capabilities required by subpart D of this part must perform its intended functions with a reliability that is comparable to that required by subpart D of this part. A launch operator shall demonstrate the reliability of a proposed alternate flight safety system through analysis, testing, and use.

(iii) The launch operator shall provide all flight safety system data required by § 415.127 of this chapter during the licensing process that is applicable to the proposed alternate flight safety system. The launch operator shall identify the similarities and differences between the design and operation of the proposed alternate flight safety system and the requirements of subpart D of this part. The launch operator shall provide an evaluation of how each difference from the requirements of subpart D of this part affects the overall safety achieved for the proposed launch.

(iv) The FAA may identify and impose additional design, test, and operational requirements for an alternate flight safety system as necessary to achieve an equivalent level of safety.

(v) A launch operator shall obtain FAA approval of any proposed alternate flight safety system that does not satisfy all of subpart D of this part before its license application or application for license modification will be found sufficiently complete to initiate review pursuant to § 413.11 of this chapter.

(b) *Public risk criteria.* A launch operator shall conduct all licensed launches in accordance with the following public risk criteria:

(1) A launch operator shall initiate flight only if the risk to the public due

to all hazards associated with the flight does not exceed an expected average number of 0.00003 casualties (E_C) per launch ($E_C \leq 30 \times 10^{-6}$), excluding water-borne vessels and aircraft. A launch operator shall determine the risk to the public from liftoff through orbital insertion for an orbital launch vehicle, and through final stage impact for a suborbital launch vehicle. A launch operator's determination of E_C for a launch shall account for, but need not be limited to, risk due to impacting debris determined in accordance with § 417.227 and any risk determined for toxic release and distant focus overpressure blast in accordance with § 417.229 and § 417.231, respectively.

(2) A launch operator shall initiate flight only if the risk to any individual member of the public does not exceed a casualty probability (P_C) of 0.000001 per launch ($P_C \leq 1 \times 10^{-6}$). A launch operator shall define an individual casualty contour in accordance with § 417.225, such that if a single person were present inside that contour at the time of liftoff, the $P_c \leq 1 \times 10^{-6}$ criteria would be exceeded. A launch operator shall treat an individual casualty contour as a safety clear zone and ensure that no member of the public is present within the contour during the flight of a launch vehicle.

(3) A launch operator shall initiate flight only if the collective risk to any water-borne vessel that is not operated in direct support of the launch does not exceed a probability of impact (P_i) of 0.00001 ($P_i \leq 1 \times 10^{-5}$) during launch vehicle flight. To ensure that this criterion is not exceeded, a launch operator shall establish each ship impact hazard area in accordance with § 417.225(g), § 417.225(i), § 417.235(c), and appendixes A and C of this part.

(4) A launch operator shall initiate flight only if the individual risk to an aircraft not operated in direct support of the launch does not exceed a probability of impact of 0.00000001 ($P_i \leq 1 \times 10^{-8}$). To ensure that this criterion is not exceeded, a launch operator shall establish each aircraft impact hazard area in accordance with § 417.225(g), § 417.225(i), § 417.235(c), and appendixes A and C of this part.

(c) *Conjunction on launch assessment.* A launch operator shall ensure that a launch vehicle, any jettisoned components, and its payload do not pass closer than 200 kilometers to a habitable orbital object throughout a sub-orbital launch. For an orbital launch, a launch operator shall ensure that a launch vehicle, any jettisoned components, and its payload do not pass closer than 200 kilometers to a habitable orbiting object during ascent

to initial orbital insertion through at least one complete orbit. A launch operator shall obtain a conjunction on launch assessment from United States Space Command in accordance with § 417.233 and shall use the results to develop flight commit criteria for collision avoidance in accordance with § 417.113(b).

(d) *Flight safety analysis.* A launch operator shall perform and document flight safety analysis in accordance with subpart C of this part. The analysis must demonstrate compliance with the public risk criteria of paragraph (b) of this section and establish flight safety limits for each launch. The flight of a launch operator's launch vehicle shall take place in accordance with the flight safety limits established pursuant to subpart C of this part. A launch operator shall use the analysis products to develop flight safety rules that govern a launch as required by § 417.113.

(e) *Radionuclides.* For launch of any radionuclide, a launch operator must, through the licensing process and in accordance with § 415.115(c) of this chapter, demonstrate clearly and convincingly that any such launch would be consistent with public health and safety. The FAA will evaluate launch of any radionuclide on a case-by-case basis, and issue an approval if the FAA finds that the launch is consistent with public health and safety.

(f) *Flight safety plan.* A launch operator shall conduct each launch in accordance with its flight safety plan that was prepared during the licensing process in accordance with § 415.115 of this chapter and updated for each launch in accordance with the launch plan requirements of § 417.111 of this chapter.

§ 417.109 Ground safety.

(a) FAA requirements for ground safety apply to launch processing at a launch site in the United States. Launch processing at a launch site outside the United States may be subject to the requirements of the governing jurisdiction.

(b) A launch operator shall protect the public from any hazards presented by operations and support systems at a launch site that are used in preparing a launch vehicle for flight. A launch operator shall perform a ground safety analysis and conduct each launch in accordance with a ground safety plan designed to protect the public from any adverse effects of preparing a launch vehicle for flight. Specific ground safety requirements that must be met by a launch operator are provided in subpart E of this part.

§ 417.111 Launch plans.

(a) A launch operator shall implement a flight safety plan, a ground safety plan, and additional written launch plans that define how launch processing and flight of a launch vehicle will be conducted without adversely affecting public safety and how to respond to accidents and other unplanned emergencies.

(b) A launch operator shall update its flight safety plan, ground safety plan, and the additional launch plans that were prepared during the licensing process in accordance with §§ 415.115, 415.117 and 415.119 of this chapter for each specific launch. A launch operator shall submit any launch plan changes or additions to the FAA no later than 15 days before the associated activity is to take place. If a change involves the addition of a new public hazard or the elimination of any control for a previously identified public hazard, a launch operator licensee shall submit a license modification request in accordance with § 415.73 and the license modification plan required by § 415.119(n) of this chapter.

(c) A launch operator shall ensure that its activities are conducted in accordance with the public safety and environmental plans and agreements of any launch site operator for the launch site from which a launch operator launches.

§ 417.113 Launch safety rules.

(a) *General.* A launch operator shall implement written safety rules that govern launch processing and flight of a launch vehicle. These launch safety rules must identify the environmental conditions and status of the launch vehicle, launch support equipment, and personnel under which launch processing and flight may be conducted without adversely affecting public safety. Launch rules must include flight safety rules that govern the flight of a launch vehicle and ground safety rules to be followed for each preflight ground operation at a launch site that has the potential to adversely affect public safety. Launch safety rules must be documented in a launch operator's launch plans. A launch operator's launch safety rules shall include those rules required by this section and any launch safety rules unique to a planned launch based on the launch operator's flight and ground safety analyses.

(b) *Flight commit criteria.* For each launch, a launch operator shall implement written flight commit criteria that identify the conditions that must be met to initiate flight. For each launch a launch operator shall document the actual conditions at the time of liftoff indicating that the flight commit criteria

have been met. A launch operator's flight commit criteria must provide for:

(1) Assurance that the time of liftoff will be such that a launch vehicle's planned trajectory will avoid habitable spacecraft in Earth orbit in accordance with § 417.107 and the results of the conjunction on launch assessment required in § 417.233.

(2) Surveillance of established hazard areas and any aircraft and ship traffic to verify that any exposure to the public satisfies the public safety criteria of § 417.107 as determined by a flight hazard area analysis performed in accordance with § 417.225.

(3) Verification that any local agreements created pursuant to § 417.7 and § 417.121(e) have been satisfied.

(4) Verification that any flight safety system is available and operational, including all required equipment and personnel.

(5) Verification that flight day meteorological conditions, such as wind, lightning, and visibility, are within required limits defined by a flight safety analysis performed in accordance with subpart C of this part. If the flight day conditions violate the meteorological limits, flight must not be initiated unless an updated analysis is performed and shows that the public risk criteria in § 417.107(b) can be met under the existing conditions. For a launch vehicle flown with a flight safety system, a launch operator shall implement weather constraints designed to avoid natural lightning strikes and lightning triggered by the flight of the launch vehicle. A launch operator's flight safety rules must include the lightning related weather constraints provided in appendix G of this part unless otherwise approved by the FAA during the licensing process based on applicability to each planned launch.

(c) *Flight termination rules.* For a launch vehicle flown with a flight safety system, a launch operator shall implement a set of written rules that specify the conditions under which flight termination shall be initiated to ensure public safety. Flight termination rules must include, but need not be limited to the following:

(1) Flight must be terminated when valid data indicate that the launch vehicle has violated a flight safety limit established by a flight safety analysis performed in accordance with § 417.213. This shall be accomplished by monitoring real-time launch vehicle flight status parameters (such as debris footprint, instantaneous impact point, or vehicle present position and velocity vector flight angles) using the flight safety data processing system and the flight safety official console in

accordance with § 417.327(f) and § 417.327(g), respectively, and initiating flight termination when a flight status parameter reaches a pre-defined flight safety limit.

(2) Flight must be terminated at the straight up time established in accordance with § 417.215 if the launch vehicle continues to fly a straight up trajectory and, therefore, does not turn downrange when it should.

(3) Flight must be terminated when real-time data provide grounds for concluding that the performance of the launch vehicle is erratic and the potential exists for the loss of flight safety system control of the launch vehicle when further flight is likely to violate the established safety criteria.

(4) A launch operator shall establish flight termination rules that apply the data loss flight times, earliest destruct time, and no longer endanger time determined in accordance with § 417.221. These flight termination rules must satisfy the following:

(i) Flight must be terminated no later than the earliest destruct time if tracking of the launch vehicle is not established and vehicle position and status data is not available to the flight safety official by the earliest destruct time.

(ii) Once launch vehicle tracking is established, if there is a loss of tracking data before the no longer endanger time and tracking data is not re-established, flight must be terminated no later than the expiration of the data loss flight time for the point in flight that the data was lost.

(5) In order to permit its launch vehicle to traverse a ''gate'' established in accordance with § 417.219, a launch operator shall verify that the launch vehicle is performing normally and shows no indication that the launch vehicle's performance will deviate from normal performance. If a launch vehicle is not performing normally immediately prior to entering a gate, the launch operator shall terminate flight. Once the launch vehicle has successfully traversed a gate, a launch operator shall not terminate flight while the launch vehicle's debris impact dispersion is over a populated or other protected area.

(d) *Launch crew work shift and rest rules.* A launch operator shall implement written rules governing the maximum length of work shifts and the amount of rest that must be afforded a launch crew. A launch operator's launch crew work shift and rest policies must provide for the following for any operation with the potential to have an adverse effect on public safety:

(1) Maximum 12-hour work shift with at least 8 hours of rest after 12 hours of work. The 8 hours of rest must be in

addition to the round trip travel time between work and home or living quarters.

(2) Maximum 60 hours worked in the preceding 7 days.

(3) Maximum of 14 consecutive work days.

(4) No more than five consecutive 12-hour work shifts shall be scheduled without a 48-hour rest period.

§ 417.115   Tests.

(a) *General.* A launch operator shall test all flight and ground systems and equipment that protect the public from any adverse effect of a launch in accordance with its test plans and procedures prepared during the licensing process in accordance with part 415, subpart F of this chapter and updated for each launch in accordance with § 417.111. A launch operator shall coordinate test plans and all associated test procedures with any launch site operator or other local entity associated with the operation. A launch operator shall determine the cause of any discrepancy identified during testing, develop and implement all corrective actions, and perform re-testing to verify each correction. A launch operator shall notify the FAA, including any onsite FAA inspector, of any discrepancy identified during testing and submit information on corrections implemented and the results of re-testing before the system or equipment is used in support of a launch.

(b) *Flight safety system testing.* A launch operator shall test any flight safety system and all flight safety system components, including any onboard launch vehicle flight termination system, command control system, and support system, in accordance with the test requirements of subpart D of this part.

(c) *Ground system testing.* A launch operator shall meet the test requirements of paragraph (a) of this section for any system or equipment used to support hazardous ground operations identified by the ground safety analysis required by § 417.405.

(d) *Communications systems testing.* A launch operator shall meet the test requirements of paragraph (a) of this section for any communication system used for voice, video, or data transmission that support a flight safety system or any other communication system that is used for a launch.

§ 417.117   Reviews.

(a) *General.* A launch operator shall conduct meetings to review the status of operations, systems, equipment, and personnel required by this part 417. A launch operator shall implement its

launch processing schedule submitted at the time of license application according to § 415.121 of this chapter and updated in accordance with § 417.9, which identifies each review to be conducted and when it is to be conducted, referenced to the planned liftoff. A launch operator shall maintain documented criteria for successful completion of each review. A launch operator shall document all review proceedings. Any corrective actions identified during a review shall be tracked to completion and documented. Launch operator personnel who oversee a review shall attest to successful completion of the review's criteria in writing. Reviews conducted by a launch operator for each launch shall include, but need not be limited to those identified in this section.

(b) *Hazardous operations safety readiness reviews.* A launch operator shall conduct a review prior to performing any hazardous operation with the potential to adversely effect public safety. The review must determine the launch operator's readiness to perform the operation and ensure that safety provisions are in place. The review must determine the readiness status of safety systems and equipment and verify that the personnel involved satisfy certification and training requirements.

(c) *Flight termination system design review.* A launch operator shall conduct a review of any onboard vehicle flight termination system and all components to ensure the design requirements have been satisfied and that the system components are ready for qualification testing in accordance with subpart D of this part.

(d) *Flight safety analysis review.* A launch operator shall conduct a flight safety analysis review to ensure that each analysis method used satisfies subpart C of this part and that the results are correct for each launch. A flight safety analysis review shall be conducted to allow any corrective actions to be completed before the launch safety review required in paragraph (f) of this section. The person who prepares the analysis must not conduct its review.

(e) *Ground safety analysis review.* A launch operator shall conduct a review of the ground safety analysis required by subpart E of this part and the status of ground safety systems, plans, procedures, and personnel that ensure public safety during ground operations. This review must be conducted in coordination with any launch site operator. A ground safety review must be successfully completed before

ground operations begin at a launch site for each launch.

(f) *Launch safety review.* For each launch, a launch operator shall conduct a launch safety review no later than 15 days prior to the planned flight day. This review must determine the readiness of ground and flight safety systems, safety equipment, and safety personnel to support a flight attempt. Successful completion of a launch safety review must ensure, but need not be limited to, satisfaction of the following criteria:

(1) Verification that all safety requirements have been or will be satisfied before flight. All safety related action items must be resolved.

(2) Flight safety personnel must be assigned and certified in accordance with § 417.105.

(3) The flight safety rules and flight safety plan must incorporate a final flight safety analysis in accordance with subpart C of this part.

(4) A ground safety analysis must be complete in accordance with subpart E of this part and the results must be incorporated into the ground safety plan. The launch operator shall verify, at the time of the review, that the ground safety systems and personnel satisfy or will satisfy all requirements of the ground safety plan for support of flight.

(5) Safety related coordination with any launch site operator or local authorities must be accomplished in accordance with local agreements.

(6) A licensee shall verify that all safety related information for a specific launch has been submitted to the FAA in accordance with FAA regulations and any special terms of a license. A licensee shall verify that information submitted to the FAA reflects the current status of safety-related systems and processes for each specific launch. A licensee shall document this verification as part of the launch license readiness statement to the FAA in accordance with § 417.9.

(g) *Launch (flight) readiness review.* A launch operator shall conduct a launch readiness review in accordance with § 415.37 of this chapter and the requirements in this section within 48 hours of the first flight attempt. A launch director, designated in accordance with § 417.103, shall review all preflight testing and launch processing conducted up to the time of the review. The status of systems and support personnel shall be reviewed to determine readiness to proceed with launch processing and the launch countdown. A decision to proceed must be in writing and signed by the launch director and any launch site operator or

federal range launch decision authority. Additional launch readiness reviews may be held at the discretion of the launch director. Information presented during a launch readiness review must address, but need not be limited to, the following:

(1) Readiness of launch vehicle and payload.

(2) Readiness of any flight safety system and personnel and the results of flight safety system testing.

(3) Readiness of all other safety-related equipment and services.

(4) Launch safety rules and launch constraints.

(5) Launch weather forecasts.

(6) Abort, hold and recycle procedures.

(7) Results of rehearsals conducted in accordance with § 417.119 of this subpart.

(8) Unresolved safety issues as of the time of the launch readiness review and plans for their resolution.

(9) Additional safety information that may be required to assess readiness for flight.

(10) Review launch failure initial response actions and investigation roles and responsibilities.

(h) *Post-launch review and report.* A launch operator shall conduct a post-launch review no later than 48 hours after completion of a launch and provide a post-launch report to the FAA no later than ten working days following completion of a launch. A launch operator shall identify any discrepancy or anomaly that occurred during the launch countdown and flight. A post-launch report must identify deviations from any term of the license or event that otherwise relate to public safety and any corrective actions to be implemented before any future launch. A post launch report must contain the results of any monitoring of flight environments performed in accordance with § 417.307(b) and any measured wind profiles used for the launch in accordance with § 417.217(d)(2). Additional post-launch review requirements that apply to launch of an unguided suborbital rocket are contained in § 417.125(j).

§ 417.119   Rehearsals.

(a) *General.* A launch operator shall rehearse the launch crew and systems to identify corrective actions needed to ensure public safety. All rehearsals shall be conducted in accordance with each of the following:

(1) A launch operator shall conduct all rehearsals in accordance with the launch processing schedule submitted at the time of license application in accordance with § 415.121 of this

chapter and any launch specific updates for each launch in accordance with § 417.9.

(2) A launch operator shall assess any anomalies identified by a rehearsal, ensure any changes needed to ensure public safety are incorporated into the launch processing and flight, and ensure the rehearsal or the related part of the rehearsal is repeated until successfully completed. A launch operator shall ensure that all rehearsals are completed at least 48 hours before the first flight attempt.

(3) A launch operator shall inform the FAA of any anomalies and related changes in operations performed during launch processing or flight resulting from a rehearsal.

(4) For each launch, each person that is to participate in the launch processing or flight of a launch vehicle shall participate in at least one related rehearsal that exercises all that person's functions.

(5) A launch operator must develop and conduct the rehearsals identified in this section for each launch unless the launch operator clearly and convincingly demonstrates an equivalent level of safety through the licensing process.

(6) Each rehearsal must simulate normal and abnormal preflight and flight conditions as needed to exercise the launch operator's launch plans.

(7) Rehearsals may be conducted at the same time provided that joint rehearsals do not create hazardous conditions, such as changing a hardware configuration that affects public safety.

(b) *Countdown rehearsal.* A launch operator shall develop and conduct a rehearsal with the countdown plan, procedures, and checklist required by § 415.119(l) of this chapter and updated as needed for each launch according to § 417.111. A countdown rehearsal must familiarize launch personnel with all countdown activities, demonstrate that the planned sequence of events is correct, and demonstrate that there is adequate time allotted for each event. A launch operator shall hold a countdown rehearsal after the launch vehicle and any launch support systems are assembled into their final configuration for flight and before the launch readiness review required by § 417.117.

(c) *Launch abort or delay recovery and recycle rehearsal.* A launch operator shall conduct a rehearsal of the launch abort or delay recovery and recycle plan developed during the licensing process in accordance with § 415.119(m) of this chapter and updated as needed for each launch in accordance with § 417.111. A launch operator shall conduct this rehearsal

after or in conjunction with a countdown rehearsal.

(d) *Emergency response rehearsal.* A launch operator shall conduct a rehearsal of the emergency response plan developed in accordance with § 415.119(b) of this chapter and updated as needed for each launch according to § 417.111. A launch operator shall conduct an emergency response rehearsal for a first launch, for any additional launch that involves a new safety hazard, for a launch where there is a change in emergency response personnel, or for any launch where more than a year has passed since the last rehearsal. An emergency response rehearsal shall be conducted in conjunction with a countdown rehearsal.

(e) *Communications rehearsal.* A launch operator shall ensure that each part of the communications plan developed according to § 415.119(f) of this chapter and updated as needed for each launch according to § 417.111, is rehearsed either in conjunction with another rehearsal or during a specific communications rehearsal.

§ 417.121 Safety critical preflight operations.

(a) *General.* A launch operator shall perform safety critical preflight operations that protect the public from the adverse effects of hazards associated with launch processing and flight of a launch vehicle. All safety critical preflight operations must be identified in the launch schedule submitted according to § 415.121 of this chapter. Safety critical preflight operations must include, but need not be limited to those defined in this section.

(b) *Countdown.* A launch operator shall conduct a launch countdown in accordance with a countdown plan, including procedures and checklists, developed during the licensing process according to § 415.119 of this chapter and which must be updated as needed for each specific launch according to § 417.111. A countdown plan must be disseminated to, and followed by, all personnel responsible for the countdown and flight of a launch vehicle. A countdown shall be communicated over a dedicated communications network that is controlled by a launch conductor responsible for ensuring that all countdown checklist items are successfully completed. A launch operator shall ensure that all channels of the communications network are recorded during each countdown. A launch conductor shall be in direct communication with launch support personnel and receive readiness

statements when checklist events are successfully completed.

(c) *Conjunction on launch assessment.* A launch operator shall coordinate with United States Space Command to obtain a conjunction on launch assessment in accordance with § 417.233. A launch operator shall develop and incorporate flight commit criteria as required by § 417.113(b) to ensure that each launch meets the criteria of § 417.107(c).

(d) *Meteorological data.* A launch operator shall conduct operations and coordinate with weather organizations as needed to ensure accurate meteorological data is obtained to support the flight safety analysis required by subpart C of this part and to ensure compliance with the flight commit criteria developed in accordance with § 417.113.

(e) *Local notification.* A launch operator shall implement any local plans and agreements developed during the licensing process according to § 415.119 of this chapter. For a launch from a site with a licensed launch site operator, the launch operator shall coordinate as needed to ensure that the launch site operator's local plans and agreements are implemented and satisfied in accordance with part 420 of this chapter. A launch operator shall ensure the following are accomplished for each launch, either as part of its local plans and agreements or as part of any launch site operator's local plans and agreements:

(1) Any local plans and agreements shall be updated to reflect each launch.

(2) Local authorities shall be informed of designated hazard areas associated with a launch vehicle's planned trajectory and any planned impacts of flight hardware as defined by the flight safety analysis required by subpart C of this part. Notifications must be designed to ensure that the public is aware of hazard areas and when to avoid them.

(3) Any hazard area information prepared in accordance with § 417.225 or § 417.235 shall be provided to the local United States Coast Guard for dissemination to mariners.

(4) Hazard area information prepared in accordance with § 417.225 or § 417.235 for each aircraft hazard area within a flight corridor shall be provided to the FAA Air Traffic Control (ATC) office having jurisdiction over the airspace through which the launch will take place for the issuance of notices to airmen.

(5) A launch operator shall be in communication with the local Coast Guard and the FAA ATC office, either directly or through any launch site operator, to ensure that notices to

airmen and mariners are issued and in effect at the time of flight.

(f) *Hazard area surveillance.* A launch operator shall implement its security and hazard area surveillance plan developed in accordance with § 415.119(h) of this chapter to ensure that the public safety criteria in § 417.107(b) are met for each launch. A launch operator shall determine any hazard areas that require surveillance in accordance with § 417.225 for an orbital launch or § 417.235 for a suborbital launch. For hazard areas requiring surveillance, a launch operator shall ensure that each hazard area is surveyed on the day of launch, and ensure that the presence of any members of the public in a surveyed hazard area is consistent with flight commit criteria developed for each launch in accordance with § 417.113. A launch operator shall verify the accuracy of any radar or other equipment used for hazard area surveillance and ensure that any inaccuracies in the surveillance system are accounted for when enforcing the flight commit criteria.

(g) *Flight safety system preflight tests.* A launch operator shall conduct preflight tests of any flight safety system in accordance with the requirements in subpart D of this part.

(h) *Launch vehicle tracking data verification.* For each launch a launch operator shall implement written procedures for verifying the accuracy of any launch vehicle tracking data provided to the flight safety official during flight. Any source of tracking data must satisfy the requirements of § 417.327(b).

(i) *Unguided suborbital rocket preflight operations.* For the launch of an unguided suborbital rocket, in addition to meeting the other requirements of this section where applicable, a launch operator shall perform the preflight wind weighting and other preflight safety operations required by § 417.125, § 417.235, and appendix C of this part.

§ 417.123 Computing systems and software.

A launch operator shall ensure that any flight and ground computing system that performs or potentially performs a software safety critical function that can affect public safety is implemented in accordance with the requirements of appendix H of this part. Software safety critical functions that apply to the launch processing and flight of a launch vehicle are defined in appendix H. A launch operator shall ensure that computing systems and software used for each launch and any process for ensuring its reliability are as

represented by the computing system and software data provided to the FAA as part of the licensing process according to § 415.123 of this chapter.

§ 417.125 Launch of an unguided suborbital rocket.

(a) *General.* In addition to meeting the other requirements contained in this subpart, a launch operator shall conduct the launch of an unguided suborbital rocket in accordance with the requirements of this section.

(b) *Flight safety.* An unguided suborbital rocket shall be launched with a flight safety system in accordance with § 417.107 (a) and subpart D of this part unless one of the following exceptions applies:

(1) The unguided suborbital rocket, including any component or payload, does not have sufficient energy to reach any protected area in any direction from the launch point; or

(2) The launch operator demonstrates through the licensing process that the launch will be conducted using a wind weighting safety system that meets the requirements of paragraph (c) of this section.

(c) *Wind weighting safety system.* A launch operator's wind weighting safety system must consist of equipment, procedures, analysis and personnel functions used to determine the launcher elevation and azimuth settings that correct for the windcocking and wind drift that an unguided suborbital rocket will experience during flight due to wind effects. The launch of an unguided suborbital rocket that uses a wind weighting safety system must meet the following requirements:

(1) The unguided suborbital rocket must not contain a guidance or directional control system.

(2) The launcher azimuth and elevation settings must be wind weighted to correct for the effects of time of flight wind conditions to provide a safe impact location. The launch shall be conducted in accordance with the wind weighting analysis requirements and methods of § 417.235 and appendix C of this part.

(3) A launch operator shall use a launcher elevation angle setting that ensures the rocket will not fly uprange. A launch operator shall set the launcher elevation angle in accordance with the following:

(i) The nominal launcher elevation angle must not exceed 85°, and must be determined based on the proximity of population to the launch point.

(ii) For an unproven unguided suborbital rocket, the nominal launcher elevation angle must not exceed 80°. A proven unguided suborbital rocket is

one that has demonstrated, by two or more launches, that flight performance errors are within all the three-sigma dispersion parameters modeled in the wind weighting safety system.

(iii) The launcher elevation angle setting may exceed the limits of paragraph (c)(3)(i) and (c)(3)(ii) of this section if the launch operator demonstrates, clearly and convincingly, an equivalent level of safety through the licensing process.

(iv) The launcher elevation angle setting need not be limited if the unguided suborbital rocket does not have sufficient energy for any component or payload to reach any protected area in any direction from the launch point.

(d) *Public risk criteria.* A launch operator shall conduct the launch of an unguided suborbital rocket in accordance with the public risk criteria in § 417.107(b). The casualty expectancy (E_C) determined prior to the day of flight must satisfy the public risk criteria for the area defined by the range of launch azimuths that the launch operator will use to accomplish wind weighting. After wind weighting on the day of flight, a launch operator shall initiate flight only after verifying that the wind drifted impacts of all planned impacts and their five-sigma dispersion areas satisfy the public risk criteria.

(e) *Stability.* An unguided suborbital rocket, in all configurations, must be stable in flexible body to 1.5 calibers and rigid body to 2.0 calibers throughout each stage of powered flight. An unguided suborbital rocket is considered stable if, when measured from the tip of the rocket's nose, the distance to the rocket's center of pressure is greater than the distance to the rocket's center of gravity for each rocket configuration for the duration of flight. A caliber, for a rocket configuration, is defined as the distance between the center of pressure and the center of gravity divided by the largest frontal diameter of the rocket configuration.

(f) *Flight safety analysis.* A launch operator shall ensure that a flight safety analysis is performed for each unguided suborbital rocket launch in accordance with § 417.235. The results of the flight safety analysis shall be used to establish launch safety rules, including launch commit criteria as required by § 417.113.

(g) *Flight safety personnel.* A launch operator shall ensure that all personnel involved in the launch of an unguided suborbital rocket are certified to perform their roles as required by § 417.105. The flight safety organization for the launch of an unguided suborbital rocket must

include the management positions and organizational elements required by § 417.103 and the following:

(1) A flight safety official who oversees launch-day activities and ensures that all launch commit criteria are met prior to flight.

(2) A wind weighting official who uses actual measured wind data and computes launch elevation and azimuth settings that correct for the wind-cocking and wind-drift effects on an unguided suborbital rocket due to wind conditions at the time of flight. The process used by a wind weighting official must satisfy the requirements of § 417.235 and appendix C of this part.

(h) *Flight safety plan.* A launch operator shall conduct a launch in accordance with its flight safety plan developed at the time of license application according to § 415.115 of this chapter and updated for each launch according to § 417.111.

(i) *Tracking.* A launch operator shall track the flight of an unguided suborbital rocket. The tracking system must provide data to determine the actual impact locations of all stages and components, to verify the effectiveness of the launch operator's wind weighting safety system, and to obtain rocket performance data for comparison with the preflight performance predictions.

(j) *Post-launch review.* A launch operator shall ensure that the post-launch review required by § 417.117(h) includes:

(1) Actual impact location of all impacting stages and any impacting components.

(2) A comparison of actual and predicted nominal performance.

(3) Investigation results of any launch anomaly. If flight performance deviates by more than a three-sigma dispersion from the nominal trajectory, the launch operator shall conduct an investigation to determine the cause of the rocket's deviation from normal flight and take corrective action before the next launch. Any corrective actions must be submitted to the FAA as a request for license modification before the next launch in accordance with § 415.73 of this chapter and the license modification plan required by § 415.119(n) of this chapter.

§ 417.127 Unique safety policies and practices.

For each launch, a launch operator shall review operations, system designs, analysis, and testing, and identify and implement any additional policies and practices needed to protect the public. These policies and practices must ensure the safety of the public. A launch operator shall implement any launch

operator unique safety policies and practices identified during the licensing process and documented in a launch operator's safety review document in accordance with § 415.125 of this chapter. For any new launch operator unique safety policy or practice or change to an existing safety policy or practice, the launch operator shall submit a request for license modification in accordance with § 415.73 of this chapter and the license modification plan required by § 415.119(n) of this chapter.

§§ 417.128—417.200 [Reserved]

Subpart C—Flight Safety Analysis

§ 417.201 Scope.

This subpart provides requirements for performing flight safety analysis in accordance with § 417.107(d) and performance standards for the analyses that a launch operator shall complete. This subpart also identifies the analysis products that a launch operator shall submit to the FAA when applying for a launch license in accordance with subpart F of part 415 of this chapter and as required by this subpart for each launch.

§ 417.203 General.

(a) *Compliance.* A launch operator shall perform flight safety analysis to demonstrate that it will monitor and control risk to the public from normal and malfunctioning launch vehicle flight in accordance with the public risk criteria of § 417.107(b) and subpart C of this part. For each launch, a licensee shall perform flight safety analysis using methods approved by the FAA during the licensing process or as a license modification. Any change to a licensee's flight safety analysis methods shall be submitted to the FAA as a request for license modification in accordance with § 415.73 of this chapter before the launch to which the proposed change applies.

(b) *Flight safety plan.* Flight safety analysis products must be incorporated in a launch operator's flight safety plan. This plan shall be prepared during the

license application process in accordance with § 415.115 of this chapter and updated to incorporate final analysis products for each launch in accordance with § 417.107(d).

(c) *Submission of analysis products.* A launch operator shall perform flight safety analysis and submit analysis products for each of the analyses required by this subpart to the FAA in accordance with the following:

(1) *License application flight safety analysis.* A launch operator shall perform flight safety analysis at the time of license application and submit the analysis products required by this subpart as part of the launch operator's safety review document in accordance with § 415.115(a) of this chapter. The FAA will evaluate the submitted analysis material to determine whether a launch operator's analysis methods for each launch are in compliance with the requirements of this subpart.

(2) *Six-month flight safety analysis.* A launch operator shall perform flight safety analysis for each launch and submit launch specific analysis products to the FAA no later than six months prior to the date of each planned flight. This analysis shall be performed with vehicle and mission specific input data as intended for the planned flight. A launch operator may reference previously submitted analysis products and data that are applicable to the launch. A launch operator shall identify any analysis product that may change as a flight date approaches. A launch operator shall describe what needs to be done to finalize any analysis product and identify when it will be finalized. The launch operator shall submit the analysis products using the same format and organization as submitted during the license application process. The FAA may request the launch operator to present the six-month flight safety analysis products in a technical meeting at the FAA.

(3) *Thirty-day flight safety analysis update.* A launch operator shall perform analysis and submit updated analysis products no later than 30 days prior to flight. The analysis must account for

potential variations in input data that may affect the analysis products within the final 30 days prior to flight. The launch operator shall submit the analysis products using the same format and organization employed during the license application process. A launch operator shall not change an analysis product within the final 30 days prior to flight unless the change is an enhancement to public safety and making the change is identified as part of the launch operator's flight safety analysis process approved by the FAA through the licensing process.

(d) *Applicability of analyses.* Flight safety analysis must assess the flight of a guided or unguided expendable launch vehicle, whether it uses a flight safety system or a wind weighting safety system to protect the public. The requirements for wind analysis of § 417.217, the debris risk analysis of § 417.227, the toxic release hazard analysis of § 417.229, the distant focus overpressure blast effects risk analysis of § 417.231, and the conjunction on launch assessment requirements of § 417.233 apply to all launches. The requirements in § 417.235 apply only to the flight of any unguided suborbital launch vehicle that uses a wind weighting safety system. All other analyses required by this subpart apply to the flight of any launch vehicle that uses a flight safety system to ensure public safety in accordance with § 417.107(a).

(e) *Dependent analyses.* Because some analyses required by this subpart are inherently dependent on one another, a launch operator shall ensure that each product or data output of any one analysis is compatible in form and content with the data input requirements of any other analysis that depends on that output. Figure 417.203–1 illustrates the flight safety analyses that would be performed for a typical launch that uses a flight safety system and the dependent relationships that exist between the analyses.

Data Source Analyses (These analyses provide data to the dependent analyses indicated with an X.)	Dependent Analyses (These analyses use data from the data source analyses indicated as input.)											
	Trajectory Analysis (§ 417.205)	Malfunction Turn (§ 417.207)	Flight Control Lines (§ 417.211)	Flight Safety Limits (§ 417.213)	Straight Up Time (§ 417.215)	No-Longer Terminate Gate (§ 417.219)	Data Loss Flight Time (§ 417.221)	Flight Hazard Areas (§ 417.225)	Debris Risk Analysis (§ 417.227)	Toxic Release Hazard Analysis (§ 417.229)	Distant Focus Overpressure Blast (§ 417.231)	Conjunction on Launch Assessment (§ 417.233)
Trajectory Analysis (§ 417.205)		X	X	X	X	X	X	X	X	X	X	X
Malfunction Turn Analysis (§ 417.207)				X	X		X	X	X	X	X	
Debris Analysis (§ 417.209)				X	X	X	X	X	X	X	X	X
Flight Control Lines (§ 417.211)				X	X	X	X	X	X	X	X	
Flight Safety Limits (§ 417.213)						X	X		X	X	X	
Straight-Up Time (§ 417.215)										X	X	
Wind Analysis (§ 417.217)	X			X	X	X	X	X	X	X	X	
No-Longer Terminate Gate (§ 417.219)							X		X	X	X	
Data Loss Flight Times (§ 417.221)		X										
Time-Delay Analysis (§ 417.223)		X		X	X	X	X	X	X	X	X	X
Flight Hazard Areas (§ 417.225)									X			

Figure 417.203-1, Illustration of Dependent Flight Safety Analyses

(f) *Alternate analysis.* A launch operator shall meet the requirements in this subpart unless the FAA approves an alternate analysis method through the licensing process. The FAA will approve an alternate method if a launch operator provides a clear and convincing demonstration that its proposed method provides an equivalent level of safety to that required by this subpart. A launch operator shall obtain FAA approval of an alternate method before the FAA will find the launch operator's license application or application for license modification sufficiently complete to initiate review pursuant to § 413.11 of this chapter. An alternate flight safety analysis method used by a federal launch range, that is documented and approved in the FAA baseline safety assessment of that federal launch range, is an acceptable alternate analysis method for a commercial launch from that range.

§ 417.205   Trajectory analysis.

(a) *General.* A launch operator shall perform a trajectory analysis to determine a launch vehicle's nominal trajectory and potential three-sigma trajectory dispersions about the nominal trajectory. A launch operator's trajectory analysis shall also determine, for any time after lift-off, the limits of a launch vehicle's normal flight. Normal flight is defined as a properly performing launch vehicle whose real-time instantaneous impact point does not deviate from the nominal instantaneous impact point by more than the sum of the wind effects and the three-sigma performance deviations in the uprange, downrange, left-crossrange, or right-crossrange directions. Figure 417.205–1 illustrates the nominal trajectory and the three-sigma left and right dispersed trajectories for a sample launch from Florida.
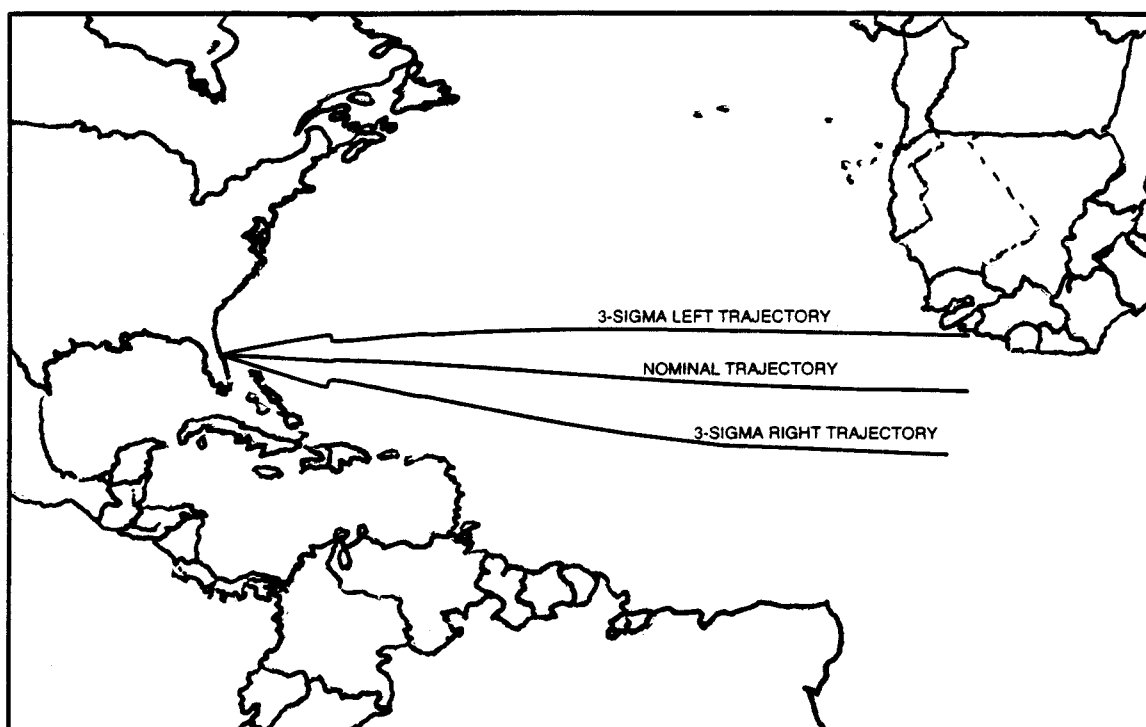
Figure 417.205-1, Illustrative Nominal and Dispersed Trajectories

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(b) *Wind standards.* A trajectory analysis shall incorporate wind data developed in accordance with the wind analysis in § 417.217 and in accordance with the following:

(1) A launch operator shall compute "with-wind" launch vehicle trajectories pursuant to § 417.205(f)(6) using annual composite wind profiles. When a launch operator will launch only at a particular time period during the year the launch operator may use the monthly composite wind for that time period.

(2) A launch operator shall compute the annual composite wind profile with a cumulative percentile frequency that represents wind conditions that are at least as severe as the worst wind conditions under which flight would be attempted. These worst wind conditions must account for the launch vehicle's ability to operate normally in the presence of wind and accommodate any flight safety limit constraints.

(c) *Nominal trajectory.* A launch operator shall compute a nominal trajectory that describes a launch vehicle's flight path, position and velocity, assuming all vehicle aerodynamic parameters are as expected, all vehicle internal and external systems perform exactly as planned, and there are no external perturbing influences other than atmospheric drag and gravity.

(d) *Dispersed trajectories.* A launch operator shall compute the following dispersed trajectories and describe a launch vehicle's position and velocity as a function of winds and three-sigma performance in the uprange, downrange, left-crossrange and right-crossrange directions.

(1) *Three-sigma maximum and minimum performance trajectories.* A launch operator shall compute a three-sigma maximum performance trajectory that provides the maximum downrange distance of the instantaneous impact point for any given time after lift-off. A launch operator shall compute a three-sigma minimum performance trajectory that provides the minimum downrange distance of the instantaneous impact point for any given time after lift-off. For any time after lift-off, the flight of a normally performing launch vehicle that is subjected to the assumed wind, shall have three-sigma impact dispersion, assuming a normal bivariate Gaussian distribution, lying between the extremes achieved at that time by the three-sigma maximum performing and three-sigma minimum performing launch vehicles.

(i) In calculating the three-sigma maximum and minimum performance trajectories, a launch operator shall use annual composite head wind and annual composite tail wind profiles that represent the worst wind conditions under which a launch would be

attempted as described in accordance with paragraph (b)(2) of this section.

(ii) The three-sigma maximum and minimum performance trajectories must account for all launch vehicle performance error parameters that have a significant effect upon instantaneous impact point range. A launch operator shall identify these parameters and incorporate them into the analysis in accordance with paragraph (f)(1) of this section.

(2) *Three-sigma left and right lateral trajectories.* A launch operator shall compute a three-sigma left lateral trajectory that provides the maximum left crossrange distance of the instantaneous impact point for any given time after lift-off. A launch operator shall compute a three-sigma right lateral trajectory that provides the maximum right crossrange distance of the instantaneous impact point for any given time after lift-off. For any time-after-liftoff, the instantaneous impact point ground trace for three-sigma of all normally performing vehicles, assuming a normal bivariate Gaussian distribution, subjected to the assumed winds, must lie between the three-sigma left lateral instantaneous impact point ground trace and the three-sigma right lateral instantaneous impact point ground trace.

(i) In calculating each left and right lateral trajectory, composite left and composite right lateral-wind profiles

shall be used which represent the worst wind conditions for which a launch would be attempted as required by paragraph (b)(2) of this section.

(ii) The three-sigma left and right lateral trajectories must account for the launch vehicle performance error parameters that have a significant effect upon the lateral deviation of the instantaneous impact point. A launch operator shall identify these performance error parameters and incorporate them into the analysis in accordance with paragraph (f)(1) of this section.

(3) *Fuel-exhaustion trajectory.* A launch operator shall compute a fuel exhaustion trajectory that is an extension of either the nominal trajectory taken through fuel exhaustion or the three-sigma maximum trajectory taken through fuel exhaustion, whichever of the two trajectories produces instantaneous impact points with the greatest range for any given time-after-liftoff. The fuel exhaustion trajectory shall be determined in accordance with the following:

(i) Trajectory data through fuel exhaustion is required even if a programmed thrust termination is scheduled in advance of fuel exhaustion.

(ii) For sub-orbital flights, fuel exhaustion trajectory data need only be determined for the last stage. Any previous stage is assumed to have nominal or three-sigma maximum performance as described by paragraph (d)(3) of this section.

(iii) For orbital flights, the fuel exhaustion trajectory data need only be determined for the last suborbital stage. Any previous stage is assumed to have nominal or three-sigma maximum performance as described by paragraph (d)(3) of this section.

(iv) The wind constraints for a fuel exhaustion trajectory shall be the same as those that apply to the nominal or three-sigma trajectory used to compute the fuel exhaustion trajectory.

(e) *Straight-up trajectory.* A launch operator shall compute a straight-up trajectory, beginning at the planned time of ignition, which simulates a malfunction that causes the launch vehicle to fly its entire flight in a vertical or near vertical direction above the launch point. The amount of time that a straight-up trajectory lasts must be no less than the sum of the straight-up time determined in accordance with § 417.215 plus the duration of a potential malfunction turn determined in accordance with § 417.207(b)(2).

(f) *Analysis process and computations.* A launch operator shall use a six-degree-of freedom trajectory model to generate each required three-sigma trajectory in terms of instantaneous impact point distance from the nominal location. In the course of generating each trajectory a launch operator shall use a root-sum-square trajectory analysis method that satisfies the requirements of paragraphs (f)(1) through (6) of this section or may employ an alternate method, such as a Monte Carlo analysis, if the launch operator demonstrates clearly and convincingly through the licensing process that its alternate method provides an equivalent level of safety. When using the root-sum-square method, a launch operator shall:

(1) *Performance error parameters.* Identify individual launch vehicle performance error parameters that contribute to the dispersion of the launch vehicle's instantaneous impact point. A launch operator shall identify all launch vehicle performance error parameters and any standard deviations for each parameter that reflect launch vehicle performance variations and any external forces that can cause offsets from the nominal trajectory during normal flight. Each dispersed trajectory must account for these performance error parameters. The performance error parameters must include thrust; thrust misalignment; specific impulse; weight; variation in firing times of the stages; fuel flow rates; contributions from the guidance, navigation, and control systems; steering misalignment; and winds.

(2) *No-wind trajectory simulation.* Perform a series of no-wind trajectory simulation runs using a six degree-of-freedom model. Each trajectory simulation run must introduce no more than one three-sigma value of a performance error parameter while all other parameters are held at nominal levels.

(3) *Tabulate individual instantaneous impact point deviations.* Tabulate at even one-second intervals, the individual downrange, uprange, left-crossrange, and right-crossrange instantaneous impact point deviations from the nominal instantaneous impact point location caused by each three-sigma value of the performance error parameters.

(4) *Combine individual instantaneous impact point deviations.* For each one-second interval, for each downrange, uprange, left crossrange, and right crossrange direction calculate the square root of the sum of the squares of all the individual instantaneous impact point deviations for each direction. The resulting values for downrange, uprange, left crossrange, and right crossrange represent the three-sigma maximum, minimum, left lateral, and right lateral instantaneous impact point deviations, respectively.

(5) *No-wind matching trajectories.* By further trajectory simulation, generate four thrusting flight no-wind trajectories that match the three-sigma instantaneous impact point deviations calculated in accordance with paragraph (f)(4) of this section.

(6) *With-wind three-sigma trajectories.* Generate each three-sigma trajectory using the worst wind conditions determined in accordance with paragraph (b) of this section and the launch vehicle performance error parameters and magnitudes used to generate the no-wind matching trajectories in accordance with paragraph (f)(5) of this section. The effect of winds on the three-sigma trajectory must be modeled from liftoff through the point in flight where the launch vehicle attains an altitude where the wind no longer affects the launch vehicle.

(g) *Trajectory analysis products.* A launch operator shall submit the products of its trajectory analysis to the FAA in accordance with § 417.203(c). Those products shall include the following:

(1) *Assumptions and procedures.* A description of all assumptions, procedures and models used in deriving the nominal and dispersed trajectories, with particular attention to the six-degrees-of-freedom model.

(2) *Three-sigma launch vehicle performance error parameter(s).* A description of the three-sigma performance error parameters accounted for by a trajectory analysis and each parameter's standard deviations determined in accordance with paragraph (f)(1) of this section.

(3) *Wind profile(s).* A graph and tabular listing of the annual winds required by paragraph (b)(1) of this section and the worst case winds required by paragraph (b)(2) of this section. The graph and tabular wind data must be the same as that used in performing the trajectory analysis and must provide wind magnitude and direction as a function of altitude for the air space regions from the Earth's surface to 100,000 feet in altitude for the area intersected by the launch vehicle trajectory. Altitude intervals must not exceed 1000 feet. Statistical wind geographic reference points shall not exceed spatial intervals greater than 2.5 degrees latitude or 2.5 degrees longitude. The graphical and tabular data shall conform to the presentation requirements of § 417.217(d)(1)(i) and § 417.217(d)(1)(ii), respectively.

(4) *Launch azimuth.* The azimuthal direction of the trajectory's "X-axis" at liftoff measured clockwise in degrees from true north.

(5) *Launch point.* Identification and location of the proposed launch point, including its name, geodetic latitude (+N), longitude (+E), and geodetic height.

(6) *Reference ellipsoid.* The name of the reference ellipsoid that the launch operator uses in performing trajectory analysis to approximate the average curvature of the Earth and the length of semi-major axis, length of semi-minor axis, flattening parameter, eccentricity, gravitational parameter, and angular velocity of the Earth at the equator. If the reference ellipsoid is not a WGS–84 ellipsoidal Earth model, the applicant shall submit the equations needed to convert the submitted ellipsoid information to the WGS–84 ellipsoid.

(7) *Temporal trajectory items.* A launch operator shall provide the following temporal trajectory data for time intervals not in excess of one second and for the discrete time points that correspond to each jettison, ignition, burnout, and thrust termination of each stage. For a sub-orbital launch vehicle, these data must account for the weight of any and all payloads to be flown and the planned nominal quadrant elevation angles of the vehicle's launcher. These data must be provided on paper in text format or electronically via disk files. The text format must have a column for each data item and a row for each time point. Disk files must be in ASCII text, space delimited format, with a column for each data item and a row for each time point. An electronic "readme" file shall be provided that clearly identifies the data, and their units of measure, in the individual disk files.

(i) *Trajectory time-after-liftoff.* Time-after-liftoff is measured from first motion of the first thrusting stage of the launch vehicle. The first motion time is identified as T–0 and shall be tabulated as the "0.0" time point on the trajectory.

(ii) *Launch Vehicle Direction Cosines.* The direction cosines of the roll axis, pitch axis, and yaw axis. The roll axis is a line identical to the launch vehicle's longitudinal axis with its origin at the nominal center of gravity positive towards the vehicle nose. The roll plane is normal to the roll axis at the vehicle's nominal center of gravity. The yaw axis and the pitch axis are any two orthogonal axes lying in the roll plane, and are chosen at the launch operator's discretion. Roll, pitch and yaw axes must be right-handed systems so that, when looking along the roll axis toward the nose, a clockwise rotation around

the roll axis will send the pitch axis toward the yaw axis. The right-handed system must be oriented such that the yaw axis is positive in the downrange direction while in the vertical position (roll axis upward from surface) or positive at an angle of 180 degrees to the downrange direction. The axis may be related to the vehicle's normal orientation with respect to the vehicle's trajectory but, once defined, remain fixed with respect to the vehicle's body. The launch operator shall indicate the positive direction of the yaw axis chosen. The reference system for the direction cosines shall be the EFG system described in paragraph (g)(7)(iv) of this section.

(iii) *X, Y, Z, XD, YD, ZD trajectory coordinates.* The launch vehicle position coordinates (X, Y, Z) and velocity magnitudes (XD, YD, ZD) must be referenced to an orthogonal, Earth-fixed, right-handed coordinate system. The XY-plane must be tangent to the ellipsoidal Earth at the origin, which is the launch point, the positive X-axis must coincide with the launch azimuth, the positive Z-axis must be directed away from the ellipsoidal Earth, and the Y-axis must be positive to the left looking downrange.

(iv) *E, F, G, ED, FD, GD trajectory coordinates.* The launch vehicle position coordinates (E, F, G) and velocity magnitudes (ED, FD, GD) must be referenced to an orthogonal, Earth fixed, Earth centered, right-handed coordinate system. The origin of the EFG system must be at the center of the reference ellipsoid. The E and F axes lie in the plane of the equator and the G-axis coincides with the rotational axis of the Earth. The E-axis is positive through 0° East longitude (Greenwich Meridian), the F-axis is positive through 90° East longitude, and the G-axis is positive through the North Pole. This system is non-inertial and rotates with the Earth.

(v) *Resultant Earth-fixed velocity.* The square root of the sum of the squares of the XD, YD, and ZD components of the trajectory state vector.

(vi) *Path angle of velocity vector.* The angle between the local horizontal plane and the velocity vector measured positive upward from the local horizontal. The local horizontal is a plane tangent to the ellipsoidal Earth at the sub-vehicle point.

(vii) *Sub-vehicle point.* Sub-vehicle point coordinates include present position geodetic latitude (+N) and present position longitude (+E). These coordinates are found at each trajectory time on the surface of the ellipsoidal Earth model and are located at the intersection of the line normal to the

ellipsoid and passing through the launch vehicle center of gravity.

(viii) *Altitude.* The distance from the sub-vehicle point to the launch vehicle's center of gravity.

(ix) *Present position arc-range.* The distance measured along the surface of the reference ellipsoid, from the launch point to the sub-vehicle point.

(x) *Total weight.* The sum of the inert and propellant weights for each time point on the trajectory.

(xi) *Total thrust.* This thrust is a scalar quantity.

(xii) *Instantaneous impact point data.* These data include instantaneous impact point geodetic latitude (+N), instantaneous impact point longitude (+E), instantaneous impact point arc-range, and time to instantaneous impact. The instantaneous impact point arc-range is the distance, measured along the surface of the reference ellipsoid, from the launch point to the instantaneous impact point. The time to instantaneous impact is the vacuum flight time remaining to impact, assuming all thrust is terminated at the associated time-after-liftoff.

(xiii) *Dynamic pressure as a function of time-of-flight.* Tabular data as part of the temporal trajectory items and a two-dimensional graph, with time-of-flight on the X-axis and dynamic pressure on the Y-axis.

(xiv) *Coriolis displacement.* The geodetic distance from the instantaneous impact point to the displacement point caused by Coriolis accelerations if this effect is not included in the trajectory computations.

(8) *Conditions for guided expendable launch vehicles.* For guided expendable launch vehicles, all trajectories must be provided from launch up to a point in flight where effective thrust of the final stage has terminated, or to thrust termination of the stage or burn that places the vehicle in orbit.

(9) *Conditions for unguided expendable launch vehicles.* For unguided expendable launch vehicles, trajectories shall be provided from launch until burnout of the final stage for each nominal quadrant elevation angle and payload weight. Time steps of the trajectory must be at even intervals, not to exceed one second increments during thrusting flight, and for discrete times corresponding to each jettison, ignition, burnout, and thrust termination of each stage. If any stage burn time is less than four seconds, time intervals must be reduced to 0.2 seconds or less.

§ 417.207 Malfunction turn analysis.

(a) *General.* A launch operator shall perform a malfunction turn analysis to

determine a launch vehicle's greatest turning capability as a function of trajectory time. A launch operator shall use the products of its malfunction turn analysis as input to its flight safety limits analysis and other analysis where it is necessary to determine how far a launch vehicle's impact point can deviate from the nominal impact point when a malfunction occurs. A launch operator shall determine the set of launch vehicle velocity vector angular deviations, measured from the nominal launch vehicle velocity vector, that cause deviation from the nominal instantaneous impact point. The velocity vector angular deviations shall be determined as a function of time, beginning at the malfunction start time. A launch operator shall also determine the corresponding change in launch vehicle velocity magnitude from the nominal velocity magnitude, as a function of time, beginning at the malfunction start time.

(b) *Malfunction turn analysis constraints.* A launch operator shall apply the following constraints to a malfunction turn analysis:

(1) A launch operator shall determine a flight safety system time delay in accordance with § 417.223 and use the results to determine the required malfunction turn duration in accordance with paragraph (b)(2) of this section.

(2) A malfunction turn shall start at a given malfunction start time and have a duration of no less than 12 seconds or the product of 1.2 times the flight safety system time delay, whichever is greater. These duration limits apply regardless of whether or not the vehicle would break up or tumble before the prescribed duration of the turn.

(3) A malfunction turn analysis must cover the thrusting periods of flight along a nominal trajectory. Malfunction turn data are required for all trajectory times from ignition to thrust termination of the final thrusting stage or until the launch vehicle achieves orbital velocity (orbital insertion), whichever occurs first.

(4) A malfunction turn must be a 90-degree turn or a turn in both the pitch and yaw planes that would produce the largest deviation from the nominal instantaneous impact point of which the launch vehicle is capable at any time during the malfunction turn. A 90-degree turn is a turn produced at the malfunction start time by instantaneously re-directing and maintaining the vehicle's thrust at 90 degrees to the velocity vector, without regard for how this situation can be brought about. A launch operator shall determine the type of turn to use as a malfunction turn in accordance with paragraph (d) of this section. If a launch operator elects not to use a 90-degree turn, the following types of turns apply when determining the malfunction turn in accordance with paragraph (d) of this section:

(i) *Pitch turn.* A pitch turn is the angle turned by the launch vehicle's total velocity vector in the pitch-plane. The velocity vector's pitch-plane is the two dimensional surface that includes the launch vehicle's yaw-axis and the launch vehicle's roll-axis. Figure 417.207–1 shows relative spatial relationships between the pitch plane, acceleration vector ($\overline{A}_o$), initial velocity vector ($\overline{V}_o$), malfunction turn velocity vector ($\overline{V}_{turn}$), angle of attack (α), and malfunction turn angle (θ). The depiction of the acceleration vector, as shown in Figure 417.207–1, was simplified by aligning it with the roll axis.
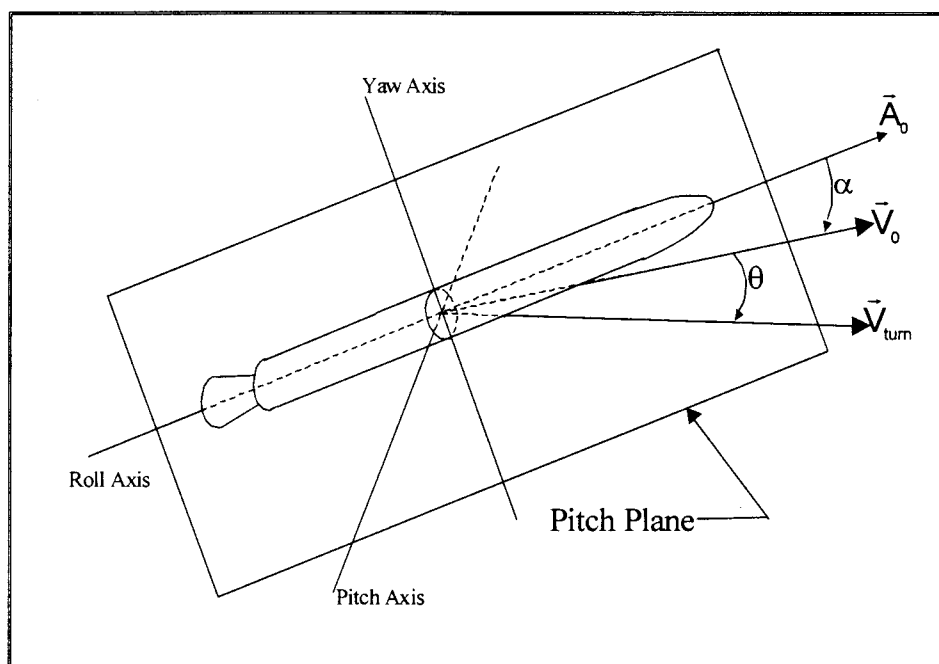

Figure 417.207-1, Pitch Plane Depiction

(ii) *Yaw turn.* A yaw turn is the angle turned by the launch vehicle's total velocity vector in the lateral plane. The velocity vector's lateral plane is the two dimensional surface that includes the launch vehicle's pitch axis and the launch vehicle's total velocity vector. Figure 417.207–2 shows relative spatial relationships between the lateral turn plane, acceleration vector ($\overline{A}_o$), initial velocity vector ($\overline{V}_o$), malfunction turn velocity vector ($\overline{V}_{turn}$), angle of attack (α), and malfunction turn angle (θ). The depiction of the acceleration vector, as shown in Figure 417.207–2, was simplified by aligning it with the roll axis. The launch operator shall measure

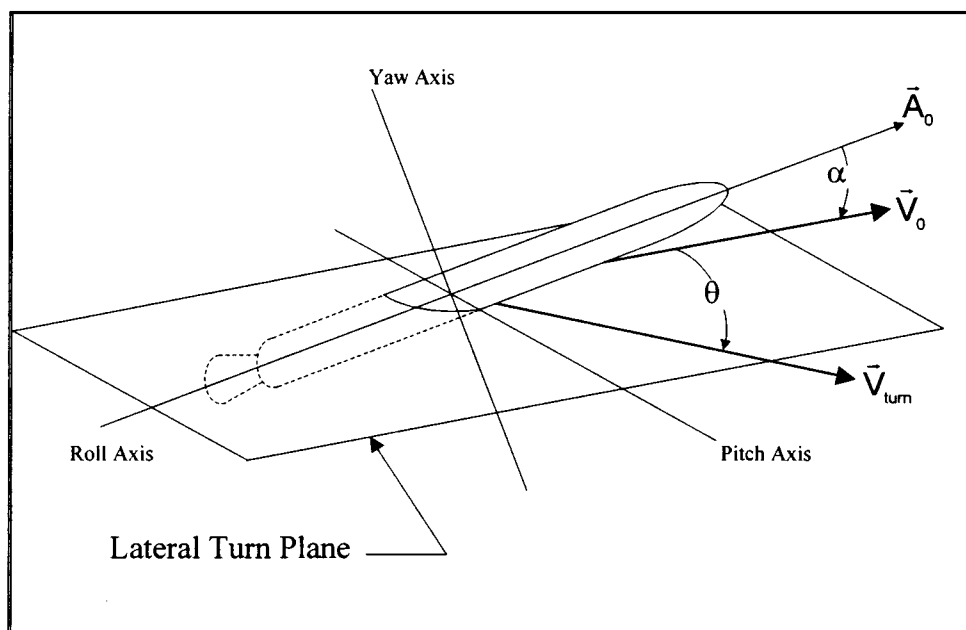the angle of attack between the roll axis and the velocity vector.

Figure 417.207-2, Lateral Turn Plane Depiction

(iii) *Trim turn.* A trim turn is a turn where a launch vehicle's thrust moment balances the aerodynamic moment while a constant rotation rate is imparted to the launch vehicle's longitudinal axis. A maximum-rate trim turn is made at or near the greatest angle of attack that can be maintained while the aerodynamic moment is balanced by the thrust moment, whether the vehicle is stable or unstable.

(iv) *Tumble turn.* A tumble turn is a turn that results if the launch vehicle's airframe rotates in an uncontrolled fashion, at an angular rate that is brought about by a thrust vector offset angle, which is held constant throughout the turn. A series of tumble turns, each turn with a different thrust vector offset angle, shall be plotted on the same graph for a given malfunction start time.

(v) *Turn envelope.* A turn envelop is a curve on a tumble turn graph that has tangent points to each individual tumble turn curve computed for a given malfunction start time. This curve envelops the actual tumble turn curves giving a prediction of tumble turn angle for data areas between the calculated turn curves. This envelope is required because an infinite number of thrust vector deviation angles is possible and it is impractical to produce a curve for each deviation angle. Figure 417.207–3 depicts a series of tumble turn curves and the tumble turn envelope curve.
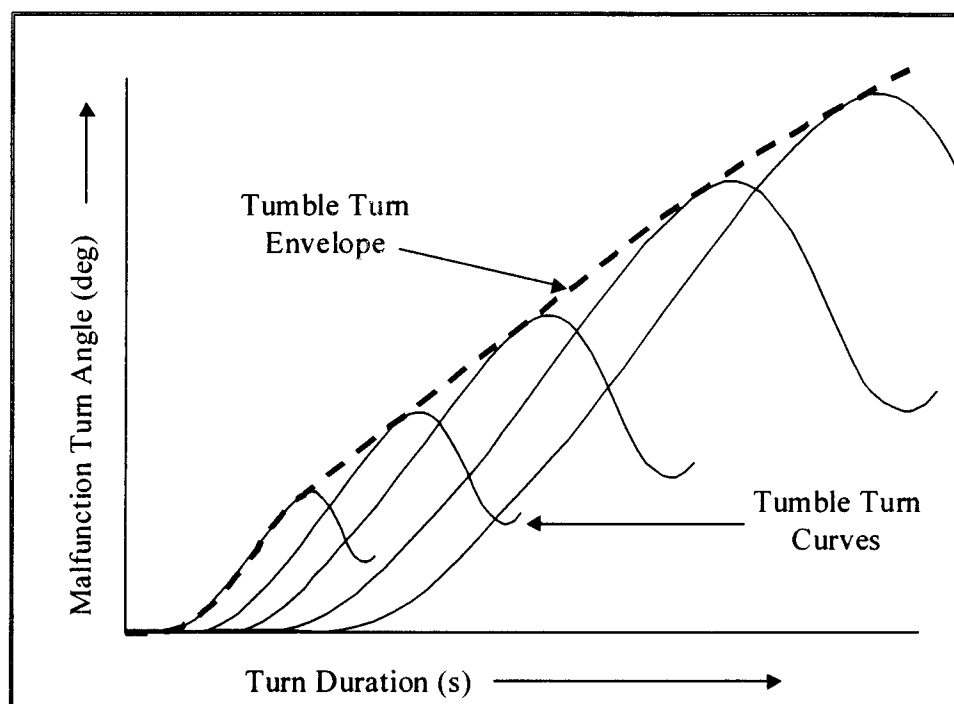
Figure 417.207-3, Illustrative Tumble Turn Envelope

(5) A launch operator's first malfunction turn start time must not be greater than the nominal trajectory time corresponding to the earliest destruct time determined in accordance with § 417.221 minus the flight safety system delay time determined in accordance with § 417.223. Subsequent malfunction turns shall be initiated at regular nominal trajectory time intervals not to exceed the flight safety system delay time.

(6) A malfunction turn analysis must provide malfunction turn computation intervals of one second over the duration of each malfunction turn.

(7) For the purposes of performing the various malfunction turn computations, a launch operator shall assume that the launch vehicle performance is nominal up to the point of the malfunction that produces the turn.

(8) A launch operator shall not include the effects of gravity in a malfunction turn analysis, unless a launch operator ensures that there is no duplication of gravity effects by any other dependent analysis that uses the products of the malfunction turn analysis as input. Other analyses that may account for gravity effects include, but need not be limited to, the flight safety limits analysis (§ 417.213), data lose flight time analysis (§ 417.221), toxic release hazard analysis (§ 417.229), distant focus overpressure blast effects risk analysis (§ 417.231), hazard areas

analysis (§ 417.225), and debris risk analysis (§ 417.227).

(9) A launch operator shall evaluate both pitch and yaw turns for malfunction start times that correspond to each sub-vehicle point. A launch operator shall use the velocity vector turn angle rate that causes the largest dispersion, from either the pitch or yaw turn computations, in the development of flight safety limits. If the pitch turn angle and yaw turn angle are the same except for the effects of gravity, the yaw turn angles may be determined from pitch calculations that, in effect, have had the gravity component subtracted out at each step in the computations.

(10) A launch operator's malfunction turn analysis shall ensure the tumble turn envelope curve maintains a positive slope throughout the malfunction turn duration as illustrated in figure 417.207–3. A launch operator may encounter a known difficulty with calculating tumble turns for an aerodynamically unstable launch vehicle. In the high aerodynamic region it often turns out that no matter how small the initial deflection of the rocket engine, the airframe tumbles through 180 degrees, or one-half cycle, in less time than the required turn duration period. In such a case, the launch operator shall use a 90-degree turn as the malfunction turn.

(c) *Failure modes.* A malfunction turn analysis must evaluate the significant

failure modes that result in a thrust vector offset from the nominal state. If the malfunction turn at a given malfunction start time can occur as a function of more than one failure mode, the launch operator must evaluate the malfunction turn for the mode causing the most rapid and largest launch vehicle instantaneous impact point deviation. Failure modes will vary as a function of flight time. The same set of failure modes shall be used for each malfunction start time where applicable to that point of a vehicle's flight.

(d) *Determining type of malfunction turn to use.* A launch operator shall establish the maximum turning capability of a launch vehicle's velocity vector based on an evaluation of trim turns and tumble turns, in both the pitch and yaw planes, or a 90-degree turn. The different types of turns are defined in paragraph (b)(4) of this section. When computing malfunction turn angles on the basis of a 90-degree turn, a launch operator shall ensure that its flight safety plan, including the flight corridor, flight safety limits, and mission rules reflect the conservative safety buffers that result from using this approach. When not using a 90-degree turn, a launch operator shall establish the launch vehicle maximum turning capability in accordance with the following malfunction turn capabilities:

(1) *Launch vehicle stable at all angles of attack.* If a launch vehicle is so stable

that the maximum thrust moment cannot produce tumbling, but produces a maximum-rate trim turn at some angle of attack less than 90 degrees, the launch operator shall determine a series of trim turns, including the maximum-rate trim turn, by varying the initial thrust vector offset at the beginning of the turn. If the maximum thrust moment results in a maximum-rate trim turn at some angle of attack greater than 90 degrees, a launch operator shall determine a series of trim turns for angles of attack up to and including 90 degrees.

(2) *Launch vehicle aerodynamically unstable at all angles of attack.* During the part of launch vehicle flight where the maximum trim angle of attack is small, tumble turns may result in the greatest malfunction turn angles. If the maximum trim angle of attack is large, trim turns may lead to higher malfunction turn angles than tumble turns. If the launch operator clearly and convincingly demonstrates that flying a trim turn even for a period of only a few seconds is impossible, the malfunction turn analysis need only determine tumble turns. Otherwise, the launch operator's malfunction turn analysis must determine a series of trim turns, including the maximum-rate trim turn, and the family of tumble turns.

(3) *Launch vehicle unstable at low angles of attack but stable at some higher angles of attack.* If large engine deflections result in tumbling, and small engine deflections do not, a series of trim and tumble turns shall be generated as required by paragraph (d)(2) of this section for launch vehicles aerodynamically unstable at all angles of attack. If both large and small constant engine deflections result in tumbling, regardless of how small the deflection might be, the malfunction turn capabilities achieved at the stability angle of attack, assuming no upsetting thrust moment, shall be used in addition to the turns achieved by a tumbling vehicle. This situation arises because the stability at high angles of attack is insufficient to arrest the angular velocity, which is built up during the initial part of a tumble turn where the launch vehicle is unstable. Although the launch vehicle cannot arrive at this stability angle of attack as a result of the constant engine deflection, there is some deflection

behavior, such as a deflection rate, that will produce this result. If a launch operator determines that arriving at such a deflection program is too difficult or too time consuming, the launch operator may assume that the launch vehicle instantaneously rotates to the trim angle of attack and stabilizes at this point. In such a case, tumble turn angles may be used during that part of launch vehicle flight for which the tumble turn envelope curve maintains a positive slope throughout the duration of the computation.

(e) *Malfunction turn analysis products.* The products of a launch operator's malfunction turn analysis to be submitted to the FAA in accordance with § 417.203(c) must include the following:

(1) A description of the assumptions, techniques, and equations used in deriving the malfunction turns.

(2) A set of sample calculations for at least one flight hazard area malfunction start time and one downrange malfunction start time. The sample computation for the downrange malfunction start time shall be at least 50 seconds greater than the flight hazard area malfunction start time or at the time of nominal thrust termination of the final stage minus the malfunction turn duration.

(3) A description of how any yaw turn angles were developed from pitch turn computations as described in paragraph (b)(9) of this section.

(4) A launch operator shall submit malfunction turn data in tabular and graphic formats. Scale factors of graphs must be selected so the plotting and reading accuracy do not degrade the accuracy of the data. For each malfunction turn start time, the time scales on malfunction velocity vector turn angle and malfunction velocity magnitude plot pairs shall be the same. Tabular listings of the data used to generate the graphs are required in digital ASCII file format. A launch operator shall submit the data items required in this paragraph for each malfunction start time. These data must be provided at intervals of one second or less over the malfunction turn duration

(i) *Velocity turn angle graphs.* For each malfunction turn angle graph, the ordinate axis must represent the total angle turned by the velocity vector, and

the abscissa axis must represent the time duration of the turn. The abscissa must be divided into one-second increments. A launch operator shall submit a graph for each malfunction start time. The series of tumble turns shall include the envelope of all tumble turn curves. The tumble turn envelope shall represent the tumble turn capability for all possible constant thrust vector offset angles (or other parameter). For this case, plots of each tumble turn curve selected to define the envelope are required on the same graph with the envelope. For trim turns, a series of trim turn curves for representative values of thrust vector offset (or other parameter) is required. The series of trim turn curves shall include the maximum-rate trim turn. Figure 417.207–4 depicts an example family of tumble turn curves and the tumble turn velocity vector envelope.

(ii) *Velocity magnitude graphs.* For each malfunction velocity magnitude graph, the ordinate axis must represent the magnitude of the velocity vector and the abscissa axis must represent the time duration of the turn. The abscissa must be divided into one-second increments. A launch operator shall submit a graph for each malfunction start time. The total velocity magnitude shall be plotted as a function of time after the malfunction start time for each thrust vector offset (or other parameter) used to define the corresponding velocity turn-angle curve. A corresponding velocity magnitude curve is required for each velocity tumble-turn angle curve and each velocity trim-turn angle curve. For each individual tumble turn curve selected to define the tumble turn envelope, its point of tangency to the envelope shall be indicated on the corresponding velocity magnitude graph. The point of tangency is the point where the tumble turn envelope is tangent to an individual tumble turn curve produced with a discrete thrust vector offset angle (or other parameter). Transposing the points of tangency to the velocity magnitude curves is accomplished by plotting a point on the velocity magnitude curve at the same time point where tangency occurs on the corresponding velocity tumble-turn angle curve. Figure 417.207–5 depicts an example tumble turn velocity magnitude curve.
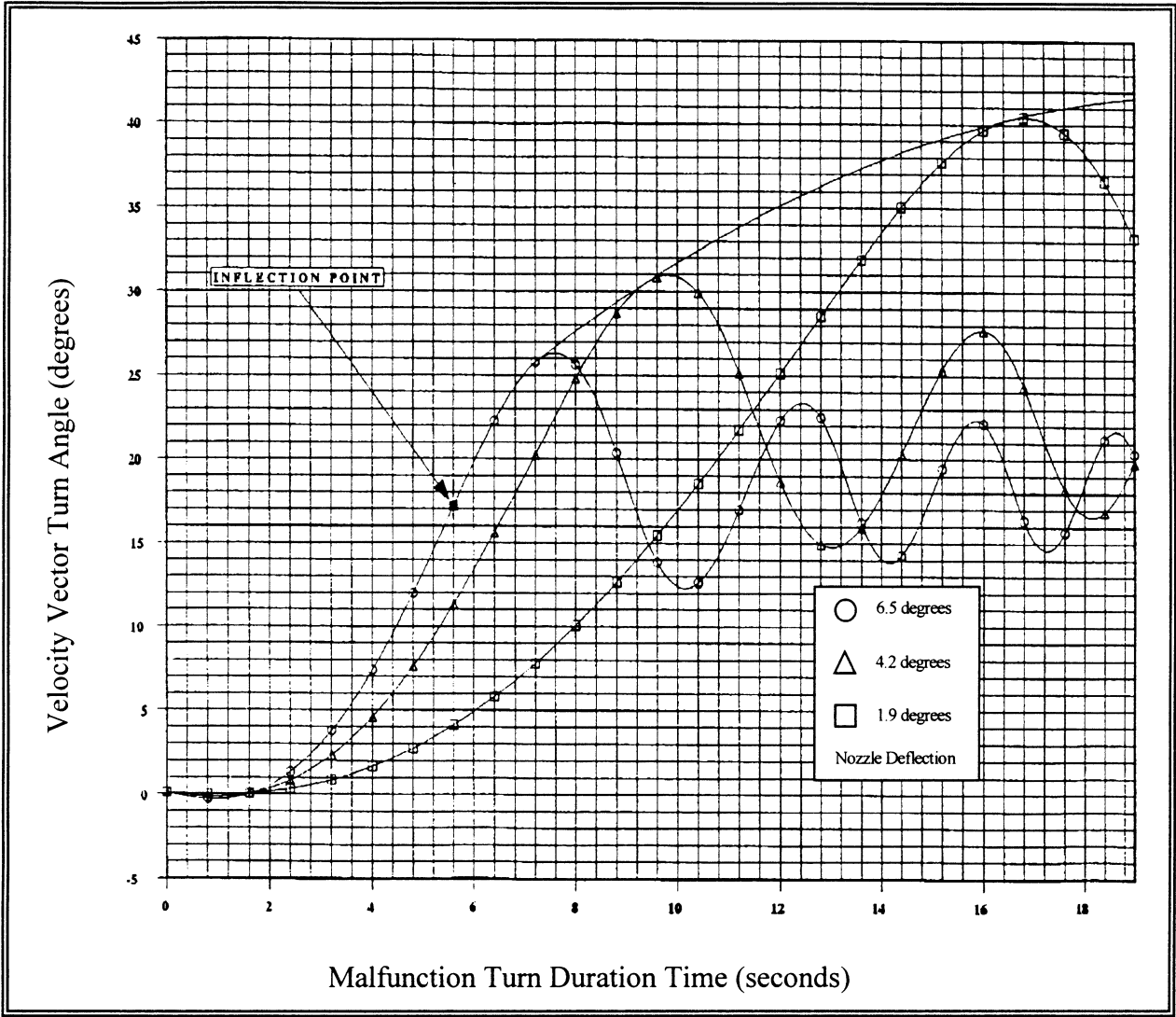
Figure 417.207-4, Example Tumble Turn Velocity Vector Turn Angle Graph.
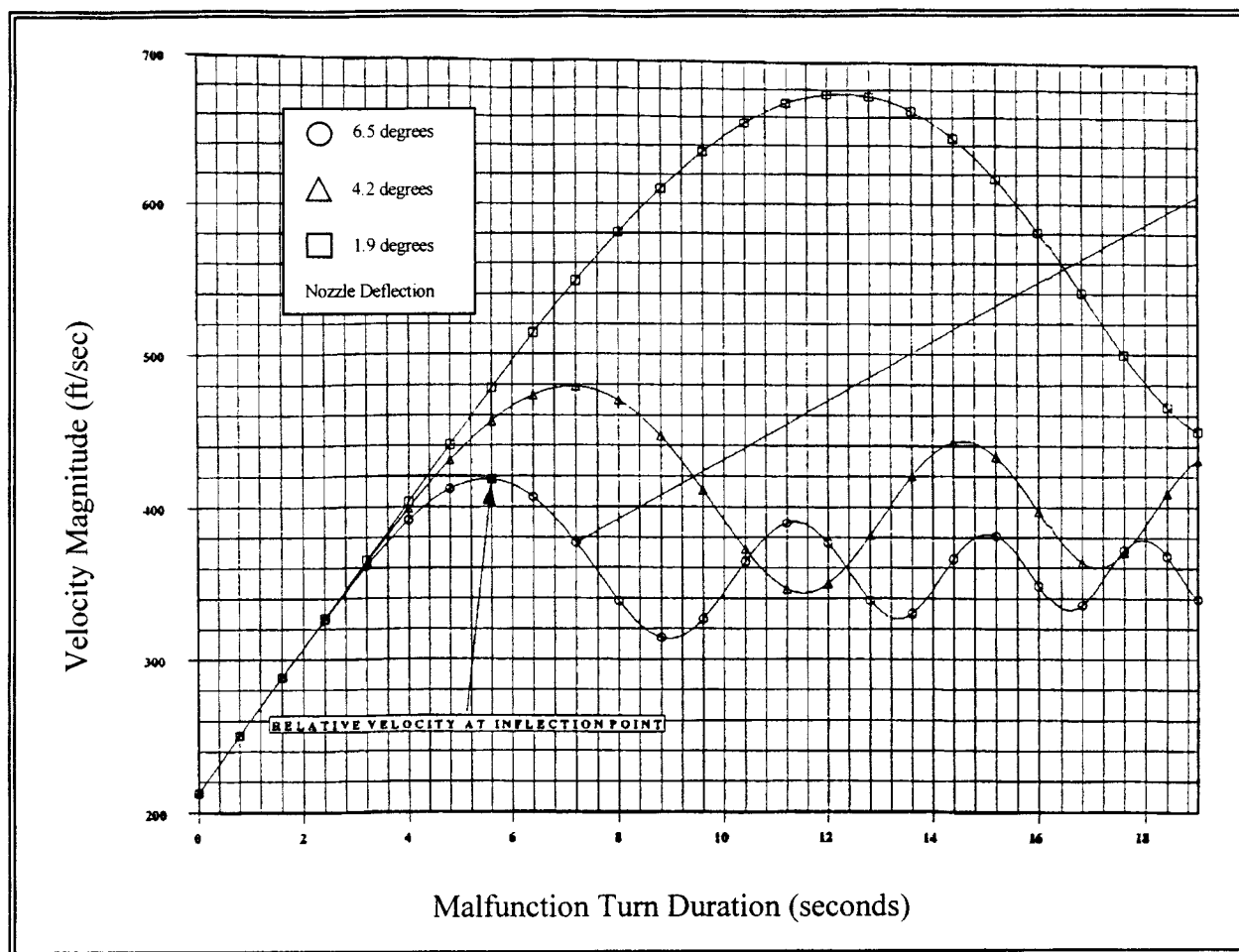
Figure 417.207-5, Illustrative Tumble Turn Velocity Magnitude Graph.

(iii) *Vehicle orientation.* If thrust-augmenting rocket motors are used on a launch vehicle, the launch operator shall submit tabular or graphical data for the vehicle attitude in the form of roll, pitch, and yaw angular orientation of the vehicle longitudinal axis as a function of time into the turn for each turn initiation time. Angular orientation of a launch vehicle's longitudinal axis is illustrated in figures 417.207–6 and 417.207–7.
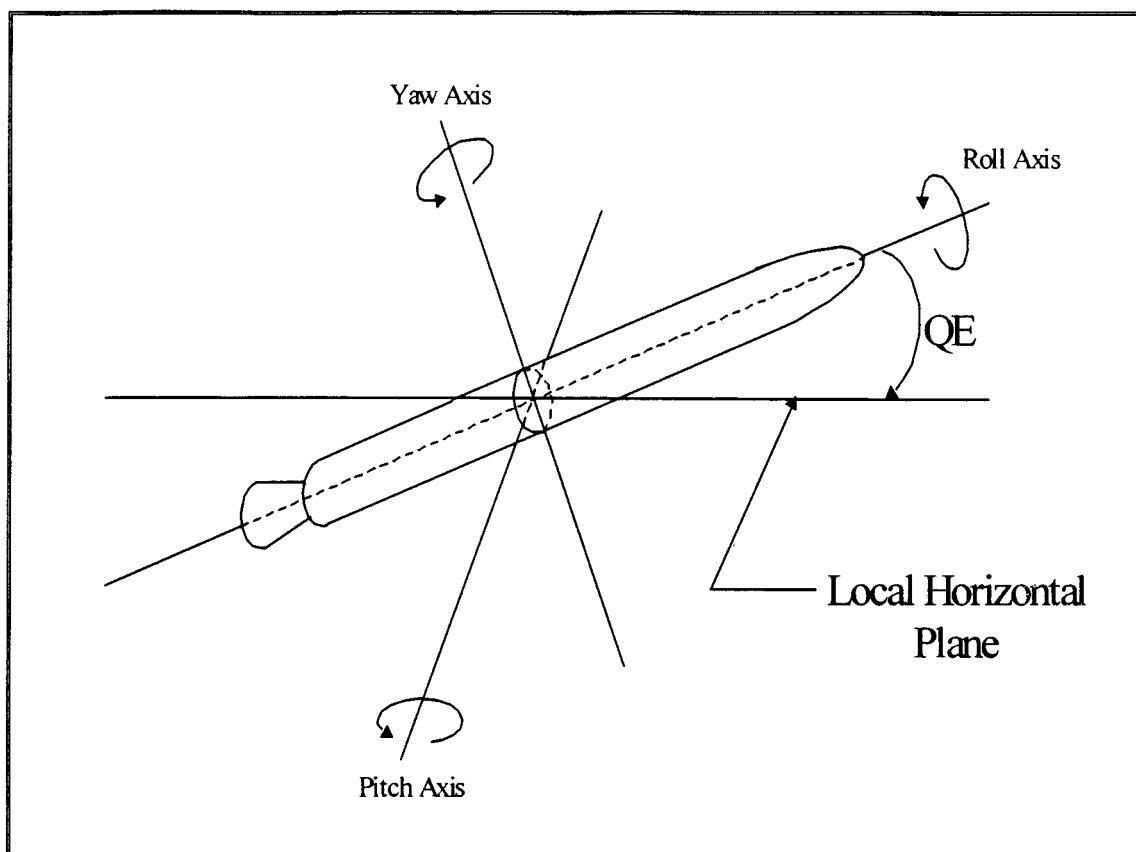
Figure 417.207-6, Illustrative Longitudinal Axis Quadrant Elevation (QE)
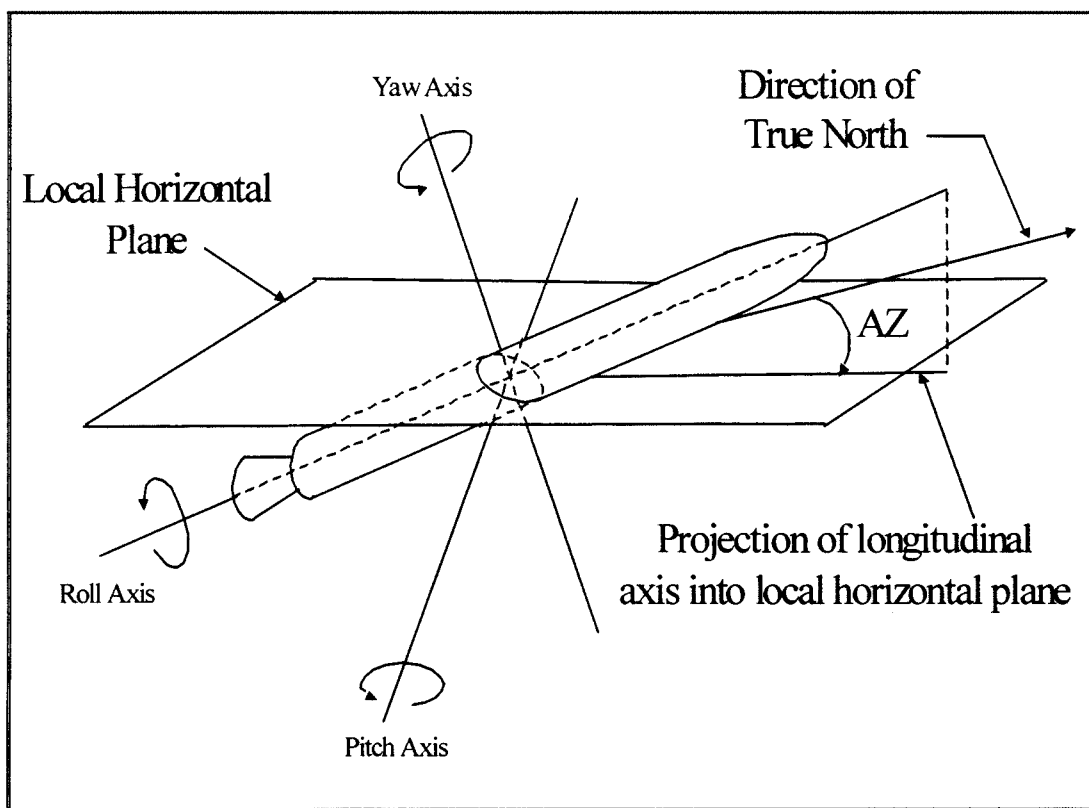
Figure 417.207-7, Illustrative Longitudinal Axis Azimuth (AZ)

(iv) *Onset conditions.* A launch operator shall provide launch vehicle state information for each malfunction start time. This state data shall include the launch vehicle thrust, weight, velocity magnitude and pad-centered topocentric X, Y, Z, XD, YD, ZD state vector.

(v) *Breakup information.* A launch operator shall specify if its launch vehicle will remain intact throughout each malfunction turn. If the launch vehicle will breakup during a turn, then the time for launch vehicle breakup must be indicated on the velocity magnitude graphs. The time into the turn at which vehicle breakup would occur must be either a specific value or a probability distribution for time to breakup.

(vi) *Inflection point.* A launch operator shall indicate the inflection point on each tumble turn envelope curve and maximum rate trim turn curve for each malfunction start time as illustrated in figure 417.207–4. The inflection point marks the point in time during the turn where the slope of the curve stops increasing and begins to decrease or, in other words, the point where the concavity of the curve changes from concave up to concave down. The inflection point on a

malfunction turn curve indicates the time in the malfunction turn that the launch vehicle body achieves a 90-degree rotation from the nominal position. On a tumble turn curve the inflection point represents the start of the launch vehicle tumble.

(vii) *Gravity effects.* A launch operator's malfunction turn analysis products must identify whether the malfunction turn analysis accounts for the effects of gravity. If the malfunction turn analysis accounts for the effects of gravity, the products must include a demonstration of how the analysis satisfies paragraph (b)(8) of this section.

§ 417.209 Debris analysis.

(a) *General.* A launch operator shall perform a debris analysis that identifies inert, explosive and other hazardous launch vehicle debris resulting from a launch vehicle malfunction and from any planned jettison of launch vehicle components for orbital and sub-orbital launch.

(b) *Debris analysis constraints.* A debris analysis must produce the debris models described in paragraphs (c) and (d) of this section, in the form of lists of debris that results from breakup of a launch vehicle and any planned jettison of debris or components. Each list must describe each debris fragment produced,

including its physical characteristics, whether it is inert or explosive, and the effects of impact, such as explosive overpressure, skip, splatter, or bounce radius. Each debris list must be produced in accordance with the following:

(1) A debris analysis must account for launch vehicle breakup caused by the activation of any flight termination system in accordance with the following:

(i) A debris analysis must account for the effects of debris produced when an intact malfunctioning vehicle is destroyed by flight termination system activation.

(ii) A debris analysis must account for spontaneous breakup of the launch vehicle assisted by the action of any inadvertent separation destruct system included as part of a flight termination system.

(iii) A debris analysis must account for the effects of debris produced when a flight termination system is activated after inadvertent breakup of the launch vehicle.

(2) A debris analysis must account for debris due to any malfunction where the launch vehicle's structural integrity limits may be exceeded.

(3) A debris analysis must account for the immediate post-breakup or jettison

environment of the launch vehicle debris, any change in debris characteristics over time from launch vehicle break-up or jettison to debris impact, and the effects of the debris upon impact.

(4) A debris analysis must account for the impact overpressure, fragmentation, and secondary debris effects of any confined or unconfined solid propellant chunks and fueled components containing either liquid or solid propellants that could survive to

impact, as a function of vehicle malfunction time.

(5) A debris analysis must account for the effects of impact of the intact vehicle as a function of failure time. The intact impact debris analysis must identify the trinitrotoluene (TNT) yield of impact explosions, and the numbers of fragments projected from all such explosions, including non-launch vehicle ejecta and the blast overpressure radius. The TNT yield of impact explosion may be estimated from

several models. The input to these models must include the propellant weight at impact, the impact speed, the orientation of the propellant, and the impacted surface material. Figure 417.209–1 shows the generic relationship between impact speed and TNT yield. A launch operator shall identify the impact yield relationship for its launch vehicle propellant for use in the debris analysis.
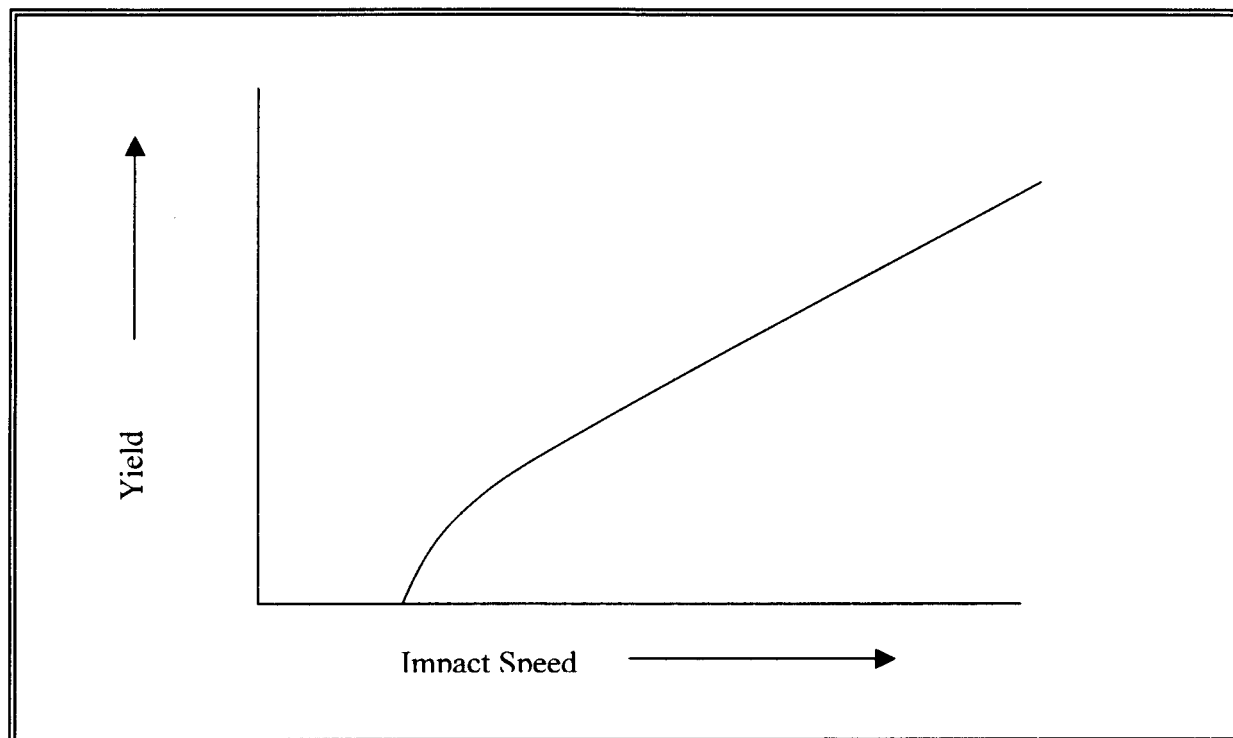

Figure 417.209-1, Generic Relationship between Yield and Impact Speed of Propellant

(c) *Debris model.* A debris analysis must produce a model of the debris resulting from unplanned breakup of a launch vehicle for use as input to other analyses, such as establishing flight safety limits and hazard areas and performing debris risk, toxic, and blast analyses. A launch operator's debris model must satisfy the following:

(1) *Debris fragments.* A debris model must contain debris fragment data for the launch vehicle flight period from the planned ignition time until the launch vehicle achieves orbital velocity for an orbital launch. For a sub-orbital launch, the debris model must contain debris fragment data for the launch vehicle flight period from the planned ignition time up to thrust termination of the last thrusting stage.

(2) *Inert fragments.* A debris model must identify all inert fragments that are

not volatile and that could not burn or explode. A debris model must identify inert fragments for each breakup time during flight corresponding to a critical event when the fragment catalog is significantly changed by the event. Critical events include staging, payload fairing jettison, or other normal hardware jettison activities.

(3) *Explosive and non-explosive propellant fragments.* A debris model must identify all propellant fragments that are explosive or non-explosive upon impact. The debris model must describe each propellant fragment as a function of time, from the time of breakup through ballistic free-fall to impact. The data shall describe the fragment characteristics, including its weight, at the time of breakup and at the time of impact. The fall time characteristics shall be described as a

function of time, such as burn rate under ambient atmospheric conditions. The time frequency of the data must represent the rate at which the fragment characteristics change so as not to reduce the accuracy of the data. The debris model shall identify the following types of propellant fragments:

(i) *Un-contained non-explosive solid propellant fragment.* Solid propellant that is exposed directly to the atmosphere and that could burn but not explode upon impact.

(ii) *Contained non-explosive propellant fragment.* Solid or liquid propellant that is enclosed in a container, such as a motor case or pressure vessel, and that could burn but not explode upon impact.

(iii) *Contained explosive propellant fragment.* Solid or liquid propellant that is enclosed in a container, such as a

motor case or pressure vessel, and that will explode upon impact.

(iv) *Un-contained explosive solid propellant fragment.* Solid propellant that is exposed directly to the atmosphere and that will explode upon impact.

(4) *Other non-inert debris fragments.* In addition to the explosive and flammable fragments required by paragraph (c)(3) of this section, a debris model must identify any other non-inert debris fragments, such as toxic or radioactive fragments, that present any other hazards to the public.

(5) *Fragment ballistic coefficient.* A debris model must include the axial, transverse, and tumble orientation ballistic coefficient for each fragment's projected area as described in paragraph (c)(8) of this section.

(6) *Fragment weight.* At each modeled breakup time, the individual fragment weights must approximately add up to the total weight of inert material in the vehicle combined with the weight of contained liquid propellants and solid propellants that are not consumed in the initial breakup or conflagration.

(7) *Fragment imparted velocity.* A debris model must include the maximum velocity imparted to each fragment due to potential explosion or pressure rupture. Unless otherwise defined by the launch operator, the velocity shall be modeled with a Maxwellian distribution with the specified maximum value equal to the 97th percentile. If the velocity distribution is different than the Maxwellian, a launch operator shall define the distribution, including whether the specified maximum value is interpreted as a fixed value with no uncertainty.

(8) *Fragment projected area.* A debris model must include the planform area of the fragment normal to the drag force at the stability angle of attack. If the fragment will not stabilize, the projected area is the tumble area normal to the drag force.

(9) *Fragment effective casualty area.* A debris model must identify the effective casualty area of each debris fragment. For inert fragments and non-explosive propellant fragments the casualty area must account for the size of the fragment, the path angle of the fragment trajectory at impact, the effects of slide, bounce and splatter produced from hard and soft surfaces, and whether a non-explosive propellant fragment is contained or un-contained. For explosive propellant fragments the effective casualty area must account for blast overpressure, non-explosive remains, ejecta originating from the impact location, and whether the

propellant fragment is contained or un-contained. For other non-inert fragments, such as toxic or radioactive fragments, the effective casualty area must account for the diffusion, dispersion, deposition, radiation or other hazard exposure characteristics of the non-inert debris and must be a circle that is defined by a hazard radius for the non-inert fragment.

(10) *Debris fragment count.* A debris model must include the total number of each type of fragment listed in paragraphs (c)(2), (c)(3), and (c)(4) of this section resulting from a malfunction.

(11) *Fragment classes.* A launch operator shall categorize malfunction debris fragments into classes where the hazards associated with the mean fragment in each class conservatively represent the hazards for every fragment in the class. A launch operator shall define fragment classes as one or more fragments whose characteristics are similar enough to allow all the fragments in the class to be described and treated by a single average set of characteristics. Fragments shall be categorized into classes in accordance with the following:

(i) A launch operator shall use fragment type as the primary parameter for categorizing fragments. All fragments within a class must be of the same type as defined in paragraphs (c)(2), (c)(3), and (c)(4) of this section.

(ii) A launch operator shall use the debris subsonic ballistic coefficient (β_{sub}) as the secondary parameter for categorizing fragments. A launch operator shall keep the difference of the smallest $\log_{10}10(\beta_{sub})$ value from the largest $\log_{10}10(\beta_{sub})$ value in a class less than 0.5.

(iii) A launch operator shall use the breakup-imparted velocity (ΔV) as the tertiary parameter for categorizing fragments. Fragments shall be categorized as a function of the range of ΔV for the fragments within a class and the class's median subsonic ballistic coefficient. For each class, a launch operator shall keep the ratio of the maximum breakup-imparted velocity (ΔV_{max}) to minimum breakup-imparted velocity (ΔV_{min}) within the following bound:

$$\frac{\Delta V_{max}}{\Delta V_{min}} < \frac{5}{1 + \log_{10}(\beta'_{sub})}$$

Where: β'_{sub} is the median subsonic ballistic coefficient for the fragments in a class.

(d) *Jettisoned body model.* A launch operator's debris analysis must produce a jettisoned body model of the launch vehicle debris resulting from scheduled

launch vehicle events for use as input to other analyses, such as the flight safety limits, hazard areas, and debris risk analyses. Jettisoned bodies include, but need not be limited to, stages, payload fairings, thrust reversal ports, solid rocket motors, attach fittings and associated hardware components. A jettisoned body model must include, but need not be limited to the following:

(1) *Jettisoned body fragment count.* The number of each type of jettisoned body resulting from a specific scheduled jettison.

(2) *Re-entry breakup.* If the jettisoned body breaks up during reentry, the launch operator's debris model must include an estimate of the number of debris fragments, their approximate weights, projected areas, and ballistic coefficients.

(3) *Jettison flight time.* The time from liftoff during normal flight that each jettison is planned to occur.

(4) *Weights.* Total weight of each jettisoned body at the time it is jettisoned.

(5) *Projected area.* The stability angle of attack planform area of the jettisoned body normal to the drag force. If the jettisoned body will not stabilize, the projected area is the tumble area normal to the drag force.

(6) *Ballistic coefficient.* The axial, transverse, and tumble orientation ballistic coefficient for each fragment's projected area as identified in accordance with paragraph (d)(5) of this section.

(e) *Debris analysis products.* A launch operator shall submit the products of its debris analysis to the FAA in accordance with § 417.203(c). Those products shall include the following:

(1) *Multiple fragment lists.* Lists of fragments that identify the variation of the fragment characteristics with breakup time.

(2) *Fragment descriptions.* A description of the fragments contained in the launch operator's debris model required by paragraph (c) of this section. The description must identify the fragment as a launch vehicle part or component, describe its shape and dimensions and include any drawings.

(3) *Minimum distance fragment.* As a function of breakup time, identification of the fragment that, in the absence of winds, will travel the least distance in comparison to all other fragments.

(4) *Intact impact TNT yield.* For an intact impact of a launch vehicle, for each failure time, a launch operator shall identify the TNT yield of each impact explosion, blast overpressure radius, and the number of fragments projected from all such explosions including non-launch vehicle ejecta.

(5) *Maximum distance fragment.* As a function of breakup time, identification of the fragment that, in the absence of winds, will travel the greatest distance in comparison to all other fragments.

(6) *Fragment class data.* The class name, boundaries of the class grouping parameters, and the number of fragments in any fragment class established in accordance with paragraph (c)(11) of this section.

(7) *Breakup altitude.* For breakup due to aerodynamic loads, inertial loads, and atmospheric reentry, identification of the range of altitudes at which breakup may occur.

(8) *Ballistic coefficient (*β*).* The mean and plus and minus three-sigma values for each fragment. A launch operator shall include graphs of the coefficient of drag (C_d) as a function of Mach number for the nominal and three-sigma beta variations for each fragment shape. Each graph must be labeled with the shape represented by the curve and reference area used to develop the curve. A launch operator shall provide a C_d vs. Mach curve for any axial, transverse, and tumble orientations for fragments that will not stabilize during free-fall conditions. For fragments that may stabilize during free-fall, a launch operator shall provide C_d vs. Mach curves for the stability angle of attack. If the angle of attack where the fragment stabilizes is other than zero degrees, a launch operator shall provide both the coefficient of lift (C_L) vs. Mach number and the C_d vs. Mach number curves. The equations for C_d vs. Mach curves shall also be provided.

(9) *Pre-flight propellant weight.* The initial preflight weight of solid and liquid propellant for each launch vehicle component that contains solid or liquid propellant.

(10) *Normal propellant consumption.* The nominal and plus and minus three-sigma solid and liquid propellant consumption rate, and pre-malfunction consumption rate for each component that contains solid or liquid propellant.

(11) *Fragment weight.* The mean and plus and minus three-sigma weight of each fragment.

(12) *Projected area.* The mean and plus and minus three-sigma axial, transverse, and tumbling areas for each fragment. This information is not required for those fragment classes classified as burning propellant classes as described in paragraph (e)(17) of this section.

(13) *Imparted velocities.* The maximum incremental velocity imparted to each fragment and the mean fragment of each fragment class created by flight termination system activation, or explosive or overpressure loads at

breakup. The launch operator shall identify the velocity distribution as Maxwellian or shall define the distribution, including whether the specified maximum value is interpreted as a fixed value with no uncertainty.

(14) *Fragment type.* The fragment type for each fragment established in accordance with paragraphs (c)(2), (c)(3), and (c)(4) of this section.

(15) *Effective casualty area.* The effective casualty area established in accordance with paragraph (c)(9) of this section for each fragment and for the effective casualty area for the mean fragment of each fragment class.

(16) *Stage of origination.* The launch vehicle stage from which each fragment originated.

(17) *Burning propellant classes.* The propellant consumption rate for those fragments that burn during free-fall.

(18) *Contained propellant fragments, explosive or non-explosive.* For fragments defined as contained propellant fragments, whether explosive or non-explosive, a launch operator shall provide the initial weight of contained propellant and the consumption rate during free-fall. The initial weight of the propellant in a contained propellant fragment is the weight of the propellant before any of the propellant is consumed by normal vehicle operation or failure of the launch vehicle.

(19) *Solid propellant fragment snuff-out pressure.* The ambient pressure and the pressure at the surface of a solid propellant fragment, in pounds per square inch, required to sustain a solid propellant fragment's combustion during free-fall.

(20) *Other non-inert debris fragments.* For each non-inert debris fragment identified in accordance with paragraph (c)(4) of this section, a launch operator shall describe the diffusion, dispersion, deposition, radiation, or other hazard exposure characteristics used to determine the effective casualty area required by paragraph (c)(9) of this section.

(21) *Residual thrust dispersion.* For each thrusting or non-thrusting stage having residual thrust capability following a launch vehicle malfunction, a launch operator shall identify either the total residual impulse imparted or the full-residual thrust in foot-pounds as a function of break-up time. For any stage not capable of thrust after a launch vehicle malfunction, a launch operator shall identify the conditions under which the stage is no longer capable of thrust. For each stage that can be ignited as a result of a launch vehicle malfunction on a lower stage, a launch operator shall identify the effects and

duration of the potential thrust, and the maximum deviation of the instantaneous impact point which can be brought about by the thrust. A launch operator shall provide the explosion effects of all remaining fuels, pressurized tanks, and remaining stages, particularly with respect to ignition or detonation of upper stages if the flight termination system is activated during the burning period of a lower stage.

(22) *Jettisoned body data.* A launch operator shall identify each scheduled jettison of any launch vehicle component, the jettison flight time, the number of jettisoned bodies resulting from each specific scheduled jettison, and the following:

(i) For a jettisoned body that will break up during reentry, the number of debris fragments, and the approximate weight, projected area, ballistic coefficient and nominal and three-sigma left crossrange, right-crossrange, uprange, and downrange impact range and the impact range distribution of each fragment. If the jettisoned body will stabilize, the launch operator shall provide the projected area as the stability angle of attack planform area of the jettisoned body normal to the drag force. If the jettisoned body will not stabilize, the projected area shall be the tumble area normal to the drag force.

(ii) Total weight of all jettisoned bodies and the weight of each jettisoned body.

(iii) For each jettisoned body, the aerodynamic reference area that is normal to the drag force and used to determine the drag coefficient data required by paragraph (e)(22)(iv) of this section.

(iv) The axial, transverse and tumbling C_d as a function of Mach number or subsonic and supersonic W/C_dA for each jettisoned body. The C_d as a function of Mach number data are to be provided in graphical format for the nominal and plus and minus three-sigma drag coefficients and shall cover the range of possible Mach numbers from zero to the maximum values during free-fall. A launch operator shall also identify whether each body is stable and, if so, at what angles of attack. For each jettisoned body that can stabilize during free-fall, a launch operator shall provide drag coefficient curves for the stability angle of attack. If the stability angle of attack is other than zero degrees, a launch operator shall also provide a graph of coefficient of lift (C_L) as a function of Mach number.

§ 417.211 Flight control lines analysis.

(a) *General.* A launch operator shall determine the geographic placement of

flight control lines that define the region over which a launch vehicle will be allowed to fly and where any debris resulting from normal flight and any launch vehicle malfunction will be allowed to impact. A launch operator shall implement flight safety limits in accordance with § 417.213 and flight termination rules in accordance with § 417.113, to ensure that debris associated with a malfunctioning launch vehicle does not impact any populated or other protected area outside the flight control lines. Flight over any populated or other protected area may be performed when a launch operator establishes a gate through a flight control line in accordance with § 417.219.

(b) *Input.* A launch operator shall obtain the following information to perform a flight control lines analysis:

(1) *Geographic data.* Geographic data includes maps, charts, or digital data depicting the geographic region protected by the flight control lines. The data must include federal, state, local and launch site boundaries and any foreign territorial boundaries, including foreign territorial waters. Depictions of the launch area landmass must include, but need not be limited to, topographical features such as elevations, rivers, lakes, and canals. Launch area landmass depictions must also include significant structures and populated areas, such as bridges, roadways, railroads, towns and cities, airports, and launch points. Downrange area landmass depictions shall include cities with populations greater than 25,000 people, country borders, national capitals and the largest city in the country. For flight control lines that encompass planned impact areas for jettisoned launch vehicle components, the data must depict land, air, and sea routes that will be the subject of notices in accordance with § 417.121. Sources of acceptable geographic data may include the National Imagery and Mapping Agency, the United States Department of Commerce, and the National Oceanic and Atmospheric Administration.

(2) *Launch vehicle trajectory data.* Launch vehicle trajectory data must describe the limits of normal launch vehicle flight, and include the launch vehicle's instantaneous impact points for the nominal, three-sigma left, and three-sigma right trajectories and the fuel exhaustion trajectories as determined by a trajectory analysis performed in accordance with § 417.205.

(3) *Special areas or zones.* Special areas or zones must include geographic descriptions of any local, state, or

federal special use areas or zones that require protection from impacting debris or that cannot accommodate the overflight of a launch vehicle.

(4) *Map errors.* A flight control lines analysis must identify direction and scale map distortions and errors as a function of distance from the point of tangency, from a parallel of true scale and true direction, or from a meridian of true scale and true direction. Map errors vary depending on the type of map projection used, such as cylindrical, conic, or plane projections used to project a round body onto a flat surface sheet. A launch operator shall select a map with a projection that accommodates the plotting technique to be used in accordance with paragraph (d) of this section. Information on calculating the error attributable to the various map projections is available from the Department of the Interior, United States Geological Survey, Geological Survey Bulletin 1532.

(5) *Tracking errors.* A flight control lines analysis must identify the crossrange, uprange, and downrange launch vehicle tracking errors in the domain of the data used to make flight control decisions, such as drag corrected impact prediction, instantaneous impact point, present position, and body attitude, or one or more combinations of these. If actual tracking error information is not available at the time of the analysis, a launch operator may use a conservative tracking error estimate. If a conservative estimate is used, a launch operator shall clearly and convincingly demonstrate that the conservative estimate exceeds the tracking source manufacturer's predicted tracking error by at least 20%. For each tracking source used for all flight termination decisions, a flight control line analysis must account for each source of significant tracking error. Sources of significant tracking error include, but need not be limited to, the following:

(i) *Radar errors.* Where radar tracking is used, a flight control lines analysis must account for radar errors due to the combination of solar heating effects, internal and external pedestal variations, antenna variations, target dependencies, signal propagation variations, refraction variations, transmitter variations, ranging variations, receiver variations, data handling effects, servo variations, and signal processing variations.

(ii) *Global Positioning System (GPS) errors.* Where GPS tracking is used, a flight control lines analysis must account for GPS errors due to the combination of satellite clock error, ephemeris error, receiver or translator

errors, delays due to satellite equipment, multi-path errors, atmosphere or ionosphere distortions, selective availability and geometric dilution of precision estimates.

(iii) *Optical errors.* Where optical tracking is used, a flight control lines analysis must account for optical tracking errors due to the combinations of azimuth and elevation biases, pitch and roll variations, non-orthogonality, optical skew, lens droop, refraction variations, atmosphere and ionosphere distortions, data handling effects, servo variations, and signal processing variations.

(c) *Flight control line constraints.* A launch operator shall apply the following constraints when generating flight control lines.

(1) Flight control lines must not extend on land beyond the area controlled by the launch operator or the launch site operator. A launch operator may establish flight control lines to protect personnel or facilities located within the area controlled by the launch operator or launch site operator. A launch operator shall establish flight control lines to protect any launch-viewing site with public access within the area controlled by the launch operator or launch site operator.

(2) Flight control lines must not intersect a foreign territorial boundary, including territorial waters, as recognized by the United States.

(3) A launch operator shall ensure that a positive mission success margin separates the launch vehicle's debris dispersion as a function of time during normal flight from the flight control lines as depicted in figure 417.211–1 of this section. This separation ensures that the flight of a normally performing launch vehicle will not be terminated. The flight control lines analysis must demonstrate a mission success margin for the most conservative normal launch vehicle trajectory relative to the flight control lines for all points along the trajectory. The launch vehicle debris dispersion at each point in time along the launch vehicle trajectory shall be determined in accordance with the flight safety limits analysis required by § 417.213.

(4) Flight control lines must border the boundaries of all protected areas. Although protected areas are populated areas and other areas from which the potential adverse effects of a launch vehicle's flight must be isolated, a protected area is not necessarily a land area. For example, a protected area may include ocean areas with high shipping or fishing traffic.

(5) Each flight control line, whether over land or water, must be offset from

any populated or other protected area by no less than a distance equal to the total of the map and launch vehicle tracking errors. Because the source of tracking data may vary throughout flight, the tracking error offset for a protected area must account for errors due to the source of tracking data for the period of flight during which the launch vehicle could reach the protected area. Map and tracking error offsets are depicted in figures 417.211–2 and 417.211–3 of this section. A launch operator may use a conservative total offset distance to simplify analysis and ease implementation of the flight control lines only if the launch operator demonstrates through the licensing process that its offset distance is greater than or equal to the total of the map and tracking errors for all protected areas.

(d) *Plotting.* A launch operator shall plot flight control lines in accordance with the following:

(1) Flight control lines must be comprised of connected geodesic-line segments of variable length that may or may not form a closed polygon, depending on the inclusion of a gate in accordance with § 417.219.

(2) When plotting flight control lines, a launch operator shall ensure that data source oblate spheroid latitude and longitude coordinates are transformed to the oblate spheroid used for the map on which the flight control lines are projected.

(3) On a map with a scale greater than or equal to 1:1,000,000 in/in, a straight flight control line segment must have a scaled distance less than or equal to 7.5 times the map scale. On a map with a scale less than 1:1,000,000 in/in, a straight flight control line segment must have scaled distances of 100 nautical miles or less.

(4) *Mechanical plotting.* A launch operator may use mechanical drafting equipment to plot the location of flight control lines on a map. The map must have a conformal conic projection.

(5) *Semi-automated plotting.* A launch operator may use range and

bearing techniques to plot latitude and longitude points on a map that has a cylindrical, conic, or plane (azimuthal) projection. Each flight control line segment must be a geodesic. Information on the various techniques for performing these calculations is available from the FAA upon request.

(6) *Fully automated plotting.* A launch operator may plot flight control lines using geographic information system software, a computer aided design system, or a computerized drawing program and global mapping data using the map projection supported by the software application. The launch operator shall ensure that each flight control line segment generated by such an automated process is a geodesic.

(e) *Flight control line analysis products.* The flight control lines analysis products, submitted to the FAA in accordance with § 417.203(c), must include:

(1) A graphic depiction of all flight control lines, the launch point, all launch site boundaries, surrounding geographic area, all protected area boundaries, and the nominal and three-sigma launch vehicle instantaneous impact point ground traces from the launch point to a distance 100 nautical miles downrange. Within 100 nautical miles of the launch point, the smallest map scale used to show flight control lines must be less than 1:15,000 inch/inches and greater than or equal to 1:250,000 inch/inches. The launch vehicle trajectory instantaneous impact points must be plotted with sufficient frequency to provide a conformal representation of the launch vehicle's instantaneous impact point ground trace curvature.

(2) A graphic depiction of all flight control lines, protected areas, and the nominal and three-sigma instantaneous impact point ground traces from liftoff through orbital insertion or final stage impact. The smallest map scales for this depiction must be greater than or equal to 1:20,000,000 inch/inches.

(3) A tabular description of the flight control lines. This must include the geodetic latitude (positive north of the equator) and longitude (positive east of the Greenwich Meridian) coordinates of both endpoints of each flight control line segment in units of decimal degrees. The quantitative values of the flight control line coordinates must be rounded to the number of significant digits that can reasonably be determined from the uncertainty of the measurement device used to determine the flight control lines. Flight control line coordinates shall be limited to a maximum of six decimal places.

(4) A map error table of direction and scale distortions as a function of distance from the point of tangency from a parallel of true scale and true direction or from a meridian of true scale and true direction. A launch operator shall provide a table of tracking error as a function of downrange distance from the launch point for each tracking station used to make flight safety control decisions. A launch operator shall submit a description of the method, showing equations and example calculations, used to determine the tracking error. The interval between map and tracking error data points within 100 nautical miles of the reference point shall be one data point every 10 nautical miles, including the reference point. The interval between map and tracking error data points beyond 100 nautical miles from the reference point shall be one data point every 100 nautical miles out to a distance that includes all flight control line endpoints.

(5) A launch operator shall provide the equations used for geodetic datum conversions and one sample calculation for converting the geodetic latitude and longitude coordinates between the datum ellipsoids used. A launch operator shall provide any equations used for range and bearing computations between geodetic coordinates and one sample calculation.
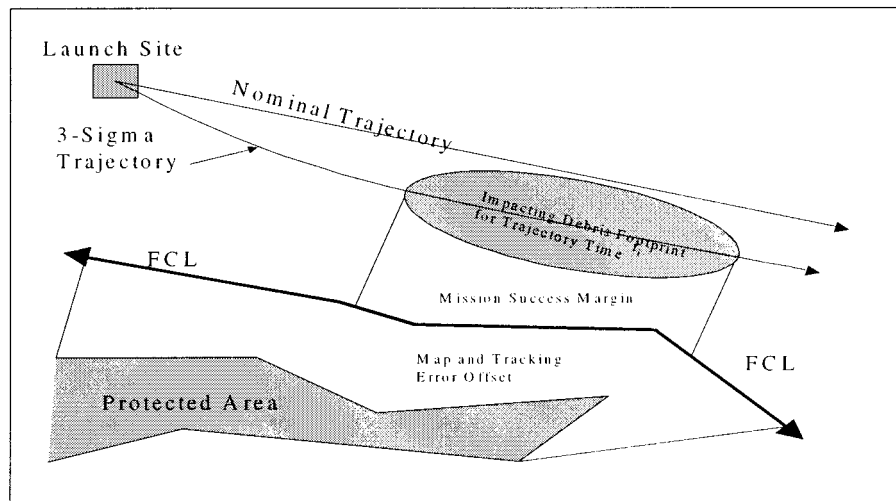
Figure 417.211-1, Illustration of Flight Control Line (FCL) Offsets and

Mission Success Margin

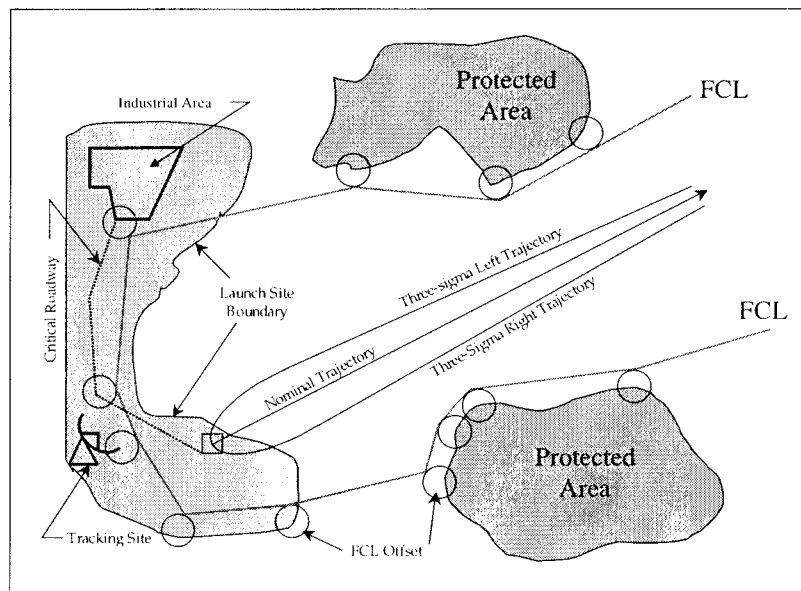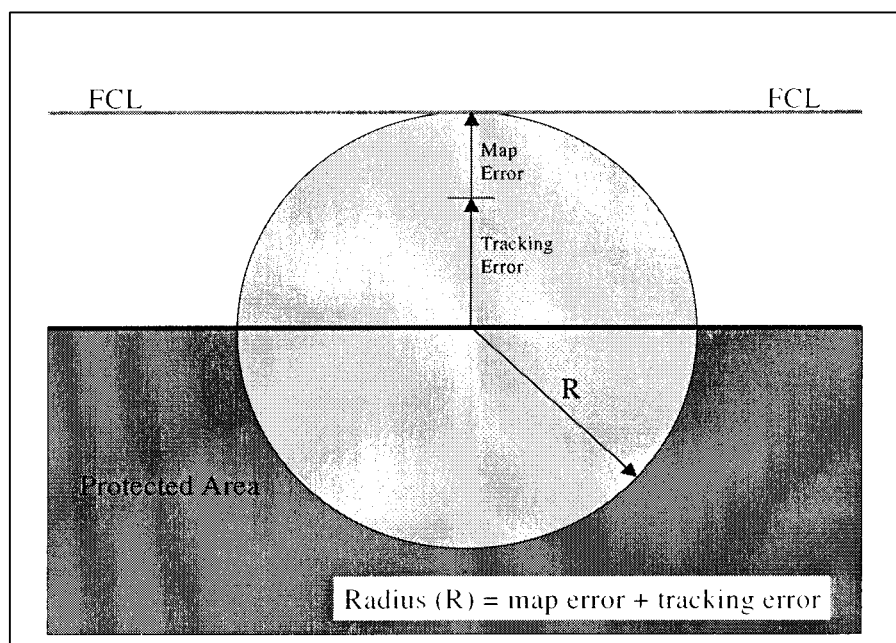**Figure 417.211-2, Illustration of Flight Control Line (FCL) Offsets**

Figure 417.211-3, Detailed Illustration of Flight Control Line (FCL) Offset

§ 417.213   Flight safety limits analysis.

(a) *General.* A launch operator shall perform a flight safety limits analysis to establish criteria for terminating a malfunctioning launch vehicle's flight. The criteria must ensure that the launch vehicle's debris impact dispersion does not extend beyond the flight control lines established in accordance with § 417.211. A launch operator's flight safety limits analysis must determine the temporal and geometric extents of a launch vehicle's debris impact dispersion on the Earth's surface resulting from any planned debris impacts and potential debris impacts created by unplanned events for any point during flight. At any time during a launch vehicle flight, a launch operator's flight safety limits must provide for the identification of a launch vehicle malfunction and the termination of flight before any adverse effects of the resulting debris could reach outside the flight control lines.

(b) *Flight safety limits constraints.* A launch operator shall apply the following constraints when establishing flight safety limits:

(1) A launch operator's flight safety limits must account for malfunctions occurring during the time from launch vehicle first motion through flight to the no longer endanger time determined in accordance with § 417.221(c).

(2) A launch operator's flight safety limits shall account for a worst case debris impact dispersion to ensure that the flight safety system is activated in sufficient time to keep the adverse

effects of any debris impacts from extending beyond the flight control lines. The worst case dispersion shall be developed by combining dispersion effects in a direction that maximizes the dispersion envelope in the uprange, downrange, right crossrange and left crossrange directions.

(3) A launch operator's flight safety limits must, for a flight termination at any time during launch vehicle flight, represent the extent of the debris impact dispersion, in the uprange, downrange and crossrange directions on the Earth's surface. The surface area bounded by the debris impact dispersion represents the geographic area that will be exposed to the adverse effects of debris impact resulting from flight termination at a given time during flight.

(4) Each debris impact area determined by a launch operator's flight safety limits analysis shall be offset from the flight control lines in a direction away from populated or other protected areas. The size of the offset shall be determined in accordance with paragraph (a) of this section based on impact dispersion parameters that include, but need not be limited to:

(i) Bounce, splatter and skip of inert debris.

(ii) Critical over-pressures greater than or equal to 3.0 psi resulting from detonation of explosive debris.

(iii) Malfunction turns.

(iv) Malfunction imparted velocities.

(v) Winds. Wind data shall be determined in accordance with § 417.217.

(vi) Residual thrust.

(vii) Guidance dispersions.

(viii) Variations in drag predictions of fragments and debris.

(ix) Other impact dispersion parameters peculiar to the launch vehicle.

(x) Debris impact location uncertainties generated from conditions prior to, and after, activation of the flight termination system.

(c) *Flight safety limits analysis products.* The products of a flight safety limits analysis to be submitted to the FAA in accordance with § 417.203(c) must include the following:

(1) A description of each method used to develop and implement the flight safety limits. The description must include equations and example computations used in the flight safety limits analysis.

(2) A description of how each analysis method meets the analysis requirements and constraints of this section, including how the method produces a worst case scenario for each impact dispersion area.

(3) A description of how the results of the analysis are used in relation to flight control lines to protect populated and other protected areas.

(4) A graphical depiction of the flight safety limits aligned on the nominal flight azimuth, the flight control lines, surrounding landmass areas within 100 nm of the flight control lines, and labeled geodetic latitude and longitude lines from liftoff to orbital insertion or the end of flight. The flight safety limits

shall be shown at trajectory time intervals sufficient to depict the mission success margin between the flight safety limits and the flight control lines. The flight safety limits shall be plotted using the same scales and frequency of plotted points as required for the flight control lines in accordance with § 417.211(e)(1) and (2).

(5) A tabular description of the flight safety limits including the geodetic latitude and longitude for each flight safety limit boundary, the nominal and three-sigma total launch vehicle velocities corresponding to each flight safety limit boundary, the altitude height from the sub-vehicle point to the launch vehicle present position, and the range and bearing from the sub-vehicle point to the vacuum impact point. This data must show the same number of significant digits as the flight control line data submitted in accordance with § 417.211(e)(3).

§ 417.215 Straight-up time analysis.

(a) *General.* A launch operator shall perform a straight-up time analysis to determine the latest time-after-liftoff by which flight termination must be initiated were a launch vehicle to malfunction and fly a vertical or near vertical trajectory (a straight-up trajectory) rather than follow a normal trajectory downrange.

(b) *Straight-up time constraints.* The following constraints apply to straight-up time analysis:

(1) A straight-up trajectory shall be defined as the flight path flown by a launch vehicle that produces vertical or near-vertical flight, beginning at liftoff.

(2) Straight-up time shall be defined as the latest time-after-liftoff, assuming a launch vehicle flies a straight-up trajectory, at which activation of the launch vehicle's flight termination system or spontaneous breakup of the launch vehicle would not cause debris or critical over-pressure to cross over any flight control line established in accordance with § 417.211.

(3) A straight-up-time analysis must account for the following:

(i) Launch vehicle trajectory.

(ii) Drag impact point of each debris fragment.

(iii) Wind effects on the drag impact point of each debris fragment.

(iv) Residual thrust effects on drag impact point of each debris fragment.

(v) Explosion velocity effects on the drag impact point of each debris fragment.

(vi) Malfunction-turn effects on the drag impact point of each debris fragment.

(vii) Distance from the launch point to any flight control line.

(viii) Delay time from the initiation of a flight termination command to actual flight termination.

(ix) Effective casualty area of each debris fragment determined in accordance with § 417.209(c)(9).

(c) *Straight-up time analysis products.* The products of a straight-up-time analysis to be submitted to the FAA in accordance with § 417.203(c) must include the following:

(1) Straight-up time.

(2) A description of the methodology used to determine straight-up time.

(3) At least one example set of straight-up-time calculations.

§ 417.217 Wind analysis.

(a) *General.* A launch operator shall perform a wind analysis to determine wind magnitude and direction as a function of altitude for the air space through which its launch vehicle will fly and for the airspace through which malfunction and jettisoned debris will travel. The products of this analysis must satisfy the input requirements of the other flight safety analyses that are dependent on wind data. A launch operator operating a suborbital launch vehicle flown with a wind weighting safety system shall meet the applicable requirements in this section and the wind analysis requirements of § 417.235(e) and appendix C of this part.

(b) *Input.* A launch operator's wind analysis must use statistical wind data, measured wind data, or a combination of statistical and measured wind data as input unless otherwise required for a specific vehicle or mission. Wind analysis input data must satisfy the following requirements:

(1) *Statistical wind data.* Statistical wind input data must include altitude, month, number of observations, mean east-west component of wind speed, standard deviation of east-west component of wind speed, mean north-south component of wind speed, standard deviation of north-south component of wind speed, and the correlation coefficient of wind components. Sources of statistical wind data include, ''Information on the Global Gridded Upper Air Statistics (GGUAS),'' dated 1980–1995, and Volume 1.1 of the same title, dated March 1996. These documents are available from the Climate Applications Branch, National Climatic Data Center, 151 Patton Ave, Room 468, Asheville, NC 28801–5001.

(2) *Measured wind data.* Measured wind input data must include altitude, wind magnitude, and wind direction.

(c) *Wind analysis constraints.* A wind analysis must incorporate the following constraints:

(1) *Altitude.* A launch operator's wind analysis must provide wind data from the altitude of the launch point to an altitude of 100,000 feet.

(2) *Azimuth.* For each of the other analyses that are dependent on wind analysis products, a launch operator shall determine wind magnitudes as a function of altitude for the worst-case wind direction (azimuth). This generally requires the determination of wind magnitudes along an azimuth that is in the direction of, and normal to, the nearest protected area such that the wind would carry any hazard toward the protected area. The wind analysis products must demonstrate how each selected azimuth represents the worst-case for its application.

(3) *Statistical winds.* When using statistical wind input data, a launch operator shall ensure that the wind analysis products represent three-sigma statistical winds assuming a one-sided normal univariate Gaussian distribution. In the absence of inter- and intra-altitude correlation coefficients, a launch operator shall ensure that wind analysis products do not exceed the altitude intervals supplied by the statistical wind input data source. Any temporal combination of statistical wind data must satisfy the following requirements:

(i) Statistical wind data shall be derived from a single data source.

(ii) Any temporal combination of statistical wind data must account for the source's temporal division of samplings, such as weeks, months, or quarters.

(iii) When performing a flight safety analysis with statistical wind data, a launch operator shall use the worst case wind from the statistical wind data source's individual temporal divisions as a function of altitude interval.

(iv) When using statistical wind data that provides height intervals in terms of millibar pressure, a launch operator shall use the mean height for the range of the temporal profile.

(4) *Measured and forecasted winds.* When using flight-day wind measurements, a launch operator shall forecast wind conditions to account for any changes that may occur between the time the measurements are made and the scheduled flight time and any planned impact time. A launch operator shall forecast wind conditions based on wind measurements taken not more than eight hours before the scheduled liftoff time and any predicted impact time. A launch operator's forecasted wind data must include a scalar wind speed that accounts for the wind measurement error created by the latency of the measured data and any

other error created by the wind measurement methods used. The following requirements apply when using flight-day wind measurements:

(i) *Launch area forecasted winds.* Using the last measured wind, a launch operator shall forecast the launch area wind speed and wind direction as a function of altitude for the scheduled flight time.

(ii) *Downrange area forecasted winds.* Using the last measured wind, a launch operator shall forecast for any predicted impact time, the downrange area wind speed and wind direction as a function of altitude in the region of the no-wind three-sigma impact dispersion of each normally jettisoned stage or component.

(5) *Wind data for trajectory analysis.* A launch operator shall select a wind profile for launch vehicle trajectory development that is as severe as the worst wind conditions under which flight might be attempted. (This wind is not necessarily the wind above which the launch vehicle would lose control or the launch vehicle would fail to maintain structural integrity. Other mission concerns may limit wind conditions.) The following constraints apply to wind analysis performed to determine the wind data needed for the development of the specific launch vehicle trajectories required by § 417.205(d):

(i) *Three-sigma maximum performance trajectory and fuel exhaustion trajectory.* For this trajectory, a wind analysis must determine the wind magnitude for each trajectory computation point, in the azimuthal direction zero degrees to the projection of the launch vehicle velocity vector azimuth into the horizontal plane that is tangent to the ellipsoidal Earth model at the launch vehicle sub-vehicle point.

(ii) *Three-sigma minimum performance trajectory.* For this trajectory, a wind analysis must

determine the wind magnitude at each trajectory computation point, in the azimuthal direction 180 degrees to the projection of the launch vehicle velocity vector azimuth into the horizontal plane that is tangent to the ellipsoidal Earth model at the launch vehicle sub-vehicle point.

(iii) *Three-sigma left lateral trajectory.* For this trajectory, a wind analysis must determine the wind magnitude at each trajectory computation point, in the azimuthal direction 90 degrees counter-clockwise to the projection of the launch vehicle velocity vector azimuth into the horizontal plane that is tangent to the ellipsoidal Earth model at the launch vehicle's sub-vehicle point.

(iv) *Three-sigma right lateral trajectory.* For this trajectory, a wind analysis must determine the wind magnitude at each trajectory computation point, in the azimuthal direction 90 degrees clockwise to the projection of the launch vehicle velocity vector azimuth into the horizontal plane that is tangent to the ellipsoidal Earth model at the launch vehicle's sub-vehicle point.

(6) *Flight safety limits.* A launch operator shall ensure that the statistical wind percentile used in developing flight safety limits in accordance with § 417.213 is such that when the flight safety limits are used during flight, a normally performing launch vehicle will not trigger flight termination. For example, a launch could not successfully take place at a given location for a given time of year where the statistical winds were such that the resulting launch vehicle debris impact dispersion, determined in accordance with § 417.213, would cross over the flight control lines, developed in accordance with § 417.211, during normal flight.

(7) *Flight constraints.* When using flight-day wind measurements, a launch

operator shall ensure wind dispersion effects based on measured and forecasted wind conditions do not exceed any statistical wind dispersion effects used in developing flight safety limits. A launch operator shall implement launch safety rules, in accordance with § 417.113, that ensure that flight will not be initiated if forecasted winds based on flight-day wind measurements invalidate any wind assumption made when developing flight safety limits.

(d) *Wind analysis products.* The products of wind analysis to be submitted to the FAA in accordance with § 417.203(c) must include the following:

(1) *Statistical wind profiles.* A launch operator shall submit a graphic and tabular description of each statistical wind profile used as input for any other flight safety analysis and an explanation of how each profile provides the worst-case wind direction safety margin required by paragraph (c)(2) of this section. A launch operator shall identify each source of its statistical wind data and submit a single graph and table for each statistical percentile and wind direction combination as follows:

(i) *Graphic description.* A launch operator shall provide a graphical depiction of each statistical wind profile for a given wind direction, showing the wind speed as a function of altitude. This plot must have the vertical axis normal to, and centered on the horizontal axis, with negative wind speeds on the left of the vertical axis and positive wind speeds on the right of the vertical axis. Zero-altitude must be positioned at the intersection of the axes and the altitudes shall be positive in the up direction. The altitude increments must not exceed 1000 feet. Figure 417.217–1 provides an example of a statistical wind profile plot.
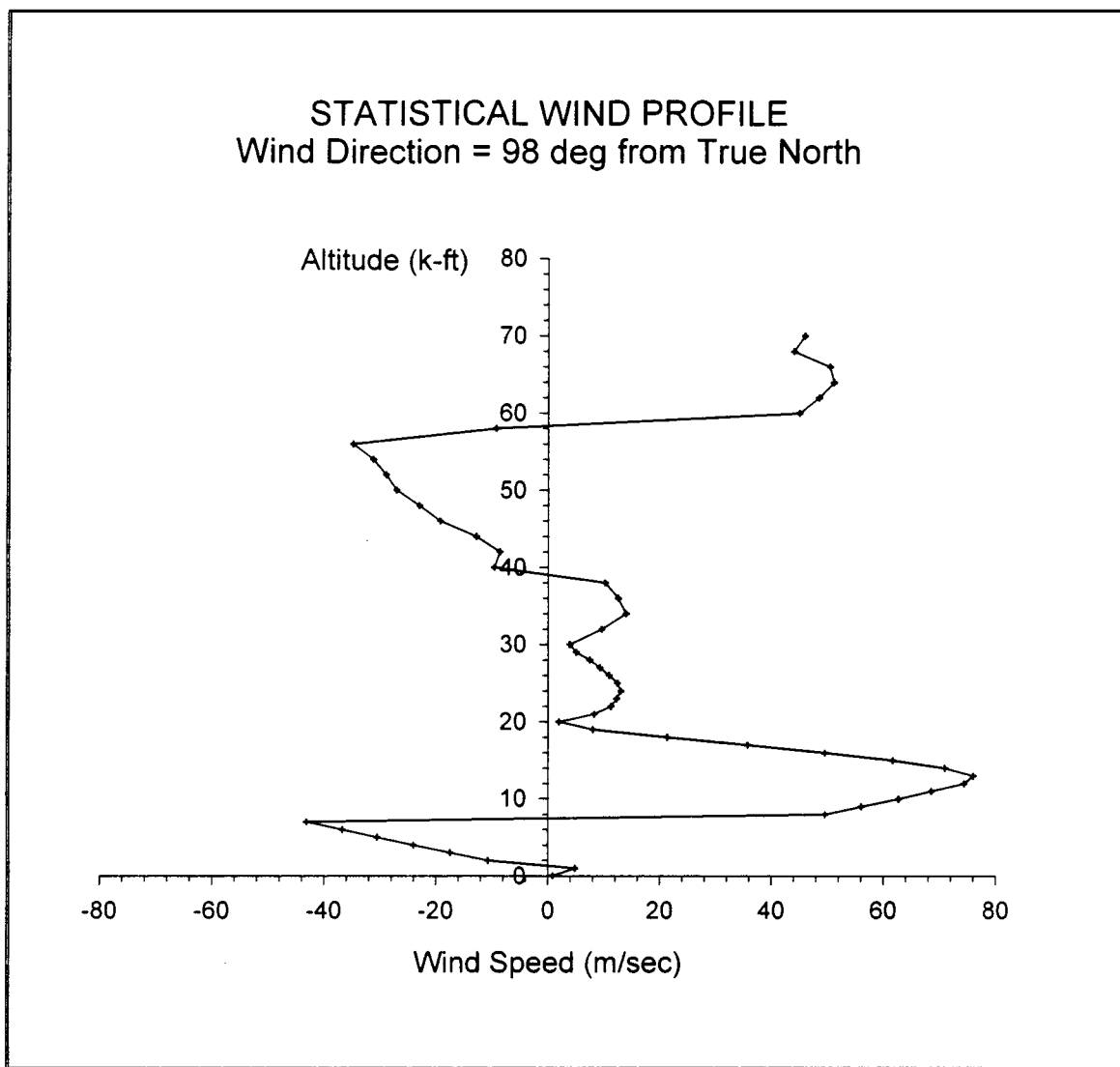
STATISTICAL WIND PROFILE
Wind Direction = 98 deg from True North

Figure 417-217-1, Example Statistical Wind Profile Plot

(ii) *Tabular description.* A launch operator shall provide a tabular description of each statistical wind profile, including the statistical wind percentile and direction of wind as the title of each table. The altitude and wind speed data must be in columnar format with altitude in column 1 and wind speed to the right side of column 1 in column 2. Altitude shall be in feet, rounded to the nearest foot, and wind speeds shall be in feet per second, rounded to two decimal places. Each altitude increment must not exceed 1000 feet.

(2) *Measured wind profile.* When using measured wind data, a launch operator shall submit a description of its process for measuring and forecasting winds in the launch area and downrange areas in accordance with paragraph (c)(4) of this section. A

launch operator shall provide a tabular description of each measured wind profile in the post launch report required by § 417.117(h). Each table shall include the launch vehicle identification, mission name, date of the measurement, time of the measurement, and the measurement source. The tabular wind data shall include the altitude, wind speed, and wind direction in columnar format, with altitude in column 1, wind speed to the right side of column 1 in column 2 and wind direction to the right of column 2 in column 3. Altitude shall be in feet, rounded to the nearest foot, wind speeds shall be in feet per second, rounded to two decimal places, and wind direction shall be in degrees measured from True North, rounded to one decimal point. Each altitude increment must not exceed 1000 feet.

(3) *Flight constraint wind data.* A launch operator shall provide the wind magnitude and wind direction information that the launch operator used to develop any wind flight constraints in accordance with paragraph (c)(7) of this section.

(4) *Wind data source information.* A launch operator shall submit a description of each wind data source, including the type of equipment used to obtain the data, measurement accuracy, and data latency to the flight safety wind analysis process.

§ 417.219 No-longer-terminate (gate) analysis.

(a) *General.* A launch operator shall perform an analysis to determine the portion, referred to as a gate, of a flight control line or other flight safety limit boundary, through which a launch

vehicle's tracking icon is allowed to proceed without a launch operator being required to terminate flight. A tracking icon is the representation of a launch vehicle's present position or instantaneous impact point position displayed to a flight safety official at the flight safety official console during real-time tracking of the launch vehicle's flight. A launch operator may use a gate for planned launch vehicle flight over a populated or other protected area only if the launch can be accomplished while meeting the public risk criteria of § 417.107(b).

(b) *No-longer-terminate (gate) analysis constraints.* The following analysis constraints apply to a gate analysis.

(1) For each gate in a flight safety limit boundary, the criteria used for determining whether to allow passage through the gate or to terminate flight at the gate must use all the same launch vehicle flight status parameters as the criteria used for determining whether to terminate flight at the flight safety limit boundary developed in accordance with § 417.213. For example, if the flight safety limits are a function of instantaneous impact point location, the

criteria for determining whether to allow passage through a gate in the flight safety limit boundary must also be a function of instantaneous impact point location. Likewise, if the flight safety limits are a function of drag impact point, the gate criteria must also be a function of drag impact point.

(2) For each established gate, the analysis must account for:

(i) Launch vehicle tracking and map errors.

(ii) Launch vehicle plus and minus three-sigma trajectory limits.

(iii) Debris impact dispersions.

(3) A gate must restrict a launch vehicle's normal trajectory ground trace, within three-sigma of nominal, to a geographic overflight region specifically defined for that gate.

(c) *No-longer-terminate (gate) products.* The products of a gate analysis to be submitted to the FAA in accordance with § 417.203(c) must include the following:

(1) A launch operator shall describe the methodology used to establish each gate.

(2) A launch operator shall submit a tabular description of the input data.

(3) A launch operator shall submit the analysis computations performed to determine a gate. If a launch involves more than one gate and the same methodology is used to determine each gate, the launch operator need only submit the computations for one of the gates.

(4) A launch operator shall submit a graphic depiction of each gate. A launch operator shall provide a small-scale depiction showing latitude and longitude grid lines, flight control lines, flight safety limits, landmass outlines, and nominal and three-sigma trajectory ground traces in their entirety. A launch operator shall also provide a large-scale depiction showing latitude and longitude grid lines, flight control lines, flight safety limits, landmass overflight regions, applicable portions of the nominal and three-sigma trajectory ground traces, and applicable predicted impact dispersion outlines. A launch operator shall show the gate latitude and longitude labels and the map scale on both depictions. Figures 417.219–1 and 417.219–2 provide examples of the gate depictions for overflight of Africa when launching from Florida.
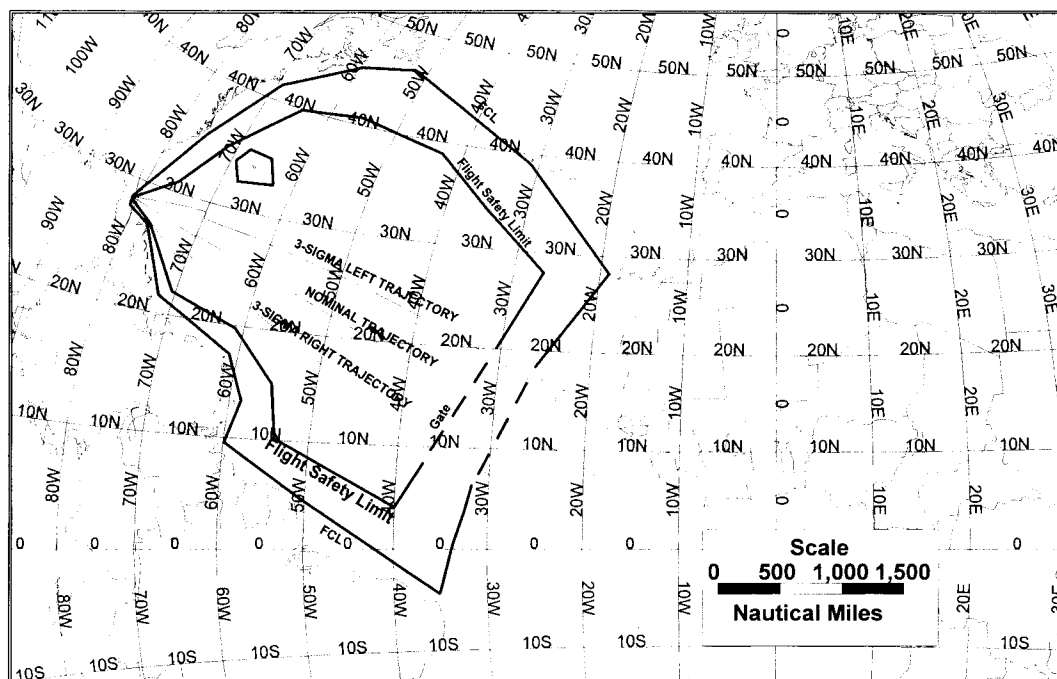

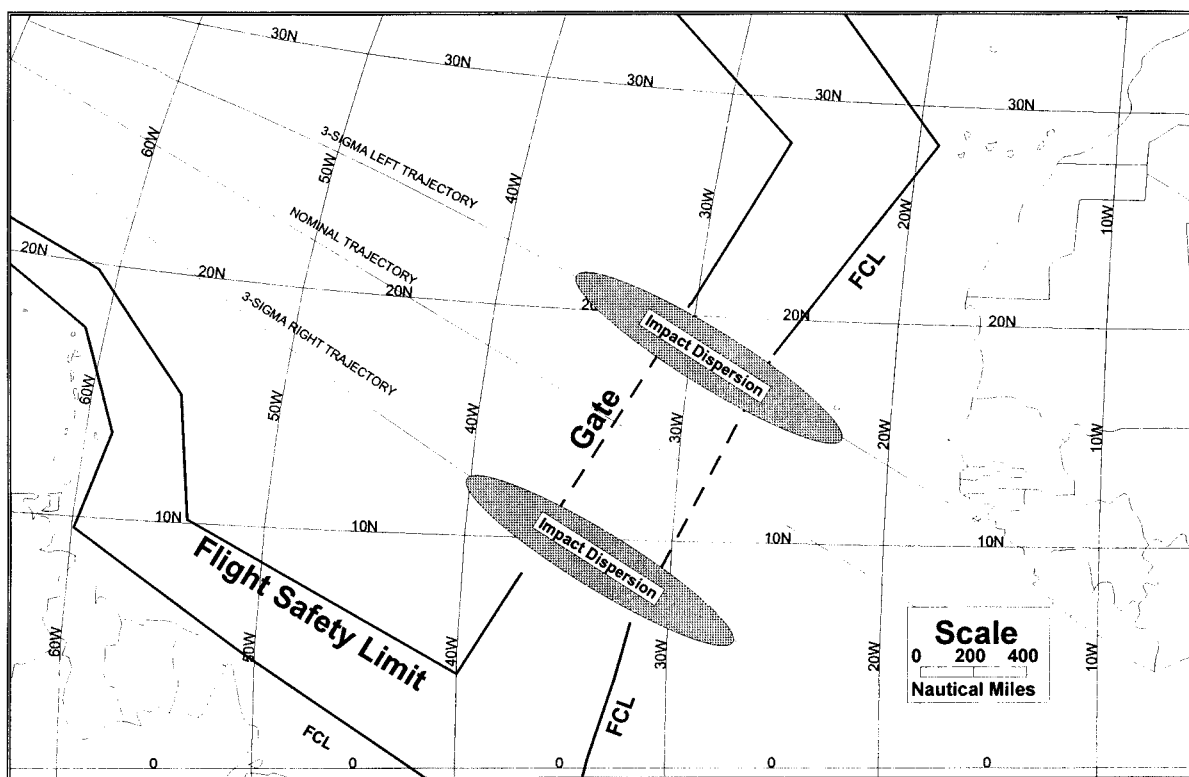**Figure 417.219-1, Example Gate Depiction (Small Scale)**

Figure 417.219-2, Example Gate Depiction (Large Scale)

§ 417.221 Data loss flight time analysis.

(a) *General.* A launch operator shall perform a data loss flight time analysis to determine the shortest elapsed thrusting time during which a launch vehicle can move from its normal trajectory to a condition where public endangerment is possible. A data loss flight time analysis must also determine an earliest destruct time, which is the earliest time after liftoff that public endangerment is possible, and a no longer endanger time, which is the time after liftoff that public endangerment is no longer possible from that time forward. Data loss flight times are used following any malfunction that prevents a flight control officer from knowing the location or behavior of a launch vehicle and that occurs during flight before the no longer endanger time is reached. A launch operator shall incorporate the results of its data loss flight time analysis into its flight termination rules in accordance with § 417.113(c).

(b) *Earliest destruct time.* A launch operator's earliest destruct time is the earliest possible time after liftoff that the launch vehicle debris impact dispersion could contact a flight control line. When calculating the earliest destruct time, the launch operator shall assume that the launch vehicle loses control immediately after ignition, that vehicle performance and orientation are optimized for maximum debris impact range, and all flight directions are equally likely. In all cases, the earliest destruct time must be greater than the predicted earliest tracking acquisition time plus the time delay determined in accordance with § 417.223.

(c) *No longer endanger time.* A launch operator's no longer endanger time is the time after liftoff after which flight termination need not be initiated even if a malfunction results in launch vehicle data loss. The no longer endanger time must be the point of orbital insertion or the nominal time after liftoff where, from that time onward, a launch vehicle no longer has the physical ability for its debris impact dispersion to contact a flight control line, whichever comes first.

(d) *Data loss flight times.* For each launch vehicle trajectory time, from the predicted earliest launch vehicle tracking acquisition time to the no longer endanger time, a launch operator shall determine the data loss flight time in accordance with the following:

(1) A data loss flight time must be the minimum thrusting time for a launch vehicle to move from a normal trajectory position to a position where a flight termination would cause the malfunction debris impact dispersion boundary to contact a flight control line.

(2) A launch operator's data loss flight time analysis must assume a malfunction that causes the launch vehicle to proceed from its position at the malfunction start time toward the flight control line, regardless of the probability of occurrence.

(3) The launch vehicle thrust vector shall be modeled to produce the highest instantaneous impact point range-rate that the vehicle is physically capable of producing at the trajectory time being evaluated, regardless of the probability of occurrence.

(4) Each data loss flight time must account for the system delays at the time of flight.

(5) A launch operator shall determine a data loss flight time for time increments of no less than one second along the launch vehicle nominal trajectory.

(e) *Data loss flight times products.* The products of a launch operator's data loss flight time analysis to be submitted in accordance with § 417.203(c) must include the following:

(1) A launch operator shall describe the methodology used in its data loss flight times analysis, including identification of all assumptions,

techniques, input data, and equations used. A launch operator shall submit calculations performed for one data loss flight time in the launch area and one data loss flight time in the downrange area. The launch area calculation time shall be separated from the downrange calculation time by at least 50 seconds, or by the greatest time otherwise feasible.

(2) A launch operator shall submit a launch area graphical description that shows flight control lines, flight safety limits, the launch point, the launch site boundaries, the surrounding geographic area, any protected areas, the earliest destruct time, the no longer endanger time (within any applicable scale requirements), latitude and longitude grid lines, and launch vehicle nominal and three-sigma instantaneous impact point ground traces from the launch point to 100 nautical miles downrange. Any launch vehicle trajectory instantaneous impact points must be plotted with sufficient frequency to provide a conformal estimate of the launch vehicle's instantaneous impact point ground trace curvature. A launch operator shall provide labeled latitude and longitude lines and the map scale on the depiction.

(3) A launch operator shall provide a downrange graphical description that shows the flight control lines, flight safety limits, all gates, protected areas, earliest destruct time, no longer endanger time, latitude/longitude grid lines, and any nominal and three-sigma instantaneous impact point ground traces from liftoff through orbital insertion or final stage impact. Any launch vehicle trajectory instantaneous impact points must be plotted with sufficient frequency to provide a conformal estimate of the launch vehicle's instantaneous impact point ground trace curvature. A launch operator shall provide labeled latitude and longitude lines and the map scale on the depiction.

(4) A launch operator shall provide a tabular description of the data loss flight times that includes malfunction start time and the geodetic latitude (positive north of the equator) and longitude (positive east of the Greenwich Meridian) coordinates of the intersection of the launch vehicle instantaneous impact point trajectory with the flight control line. The earliest destruct time and no longer endanger time shall be identified in the table. The tabular description must include data loss flight times for trajectory time increments not to exceed one second.

§ 417.223 Time delay analysis.

(a) *General.* A launch operator shall perform a time delay analysis to determine the mean elapsed time between the start of a launch vehicle malfunction and the final commanded flight termination. The time delay must include a flight safety official's decision and reaction time. A launch operator shall also determine the time delay plus and minus three-sigma values relative to the mean time delay.

(b) *Time delay analysis constraints.* A time delay analysis shall account for data flow rates and reaction times due to hardware and software and decision and reaction times due to personnel that comprise a launch operator's flight safety system as defined by subpart D of this part. A launch operator shall conduct time delay analyses for all data used by a flight safety official for making flight termination decisions. A launch operator's time delay analysis shall account for all significant causes of delay in receiving data. A launch operator's time delay analysis shall account for all delays caused by hardware and software, including, but not limited to, the following:

(1) *Tracking system.* A launch operator's time delay analysis must account for delays associated with the hardware and software that make up the launch vehicle tracking system, whether or not it is located on the launch vehicle, such as transmitters, receivers, decoders, encoders, modulators, circuitry and any encryption and decryption of data.

(2) *Display systems.* A launch operator's time delay analysis must account for delays associated with hardware and software that make up any display system used by a flight safety official to aid in making flight control decisions. A launch operator's time delay analysis must also account for any manual operations requirements, tracking source selection, tracking data processing, flight safety limit computations, inherent display delays, meteorological data processing, automated or manual system configuration control, automated or manual process control, automated or manual mission discrete control, and automated or manual failover decision control.

(3) *Flight termination system and command control system.* A launch operator's time delay analysis must account for delays and response times associated with flight termination system and command control system hardware and software, such as transmitters, decoders, encoders, modulators, relays and shutdown, arming and destruct devices, circuitry

and any encryption and decryption of data.

(4) *Software specific time delays.* A launch operator's time delay analysis must account for delays associated with any correlation of data performed by software, such as timing and sequencing; data filtering delays such as error correction, smoothing, editing, or tracking source selection; data transformation delays; and computation cycle time.

(c) *Time delay analysis products.* The products of a launch operator's time delay analysis to be submitted in accordance with § 417.203(c) must include the following:

(1) A description of the methodology used to produce the time delay analysis.

(2) A schematic drawing that maps the flight control official's data flow time delays from the start of a launch vehicle malfunction through the final commanded flight termination on the launch vehicle, including the flight safety official's decision and reaction time. The drawings shall indicate major systems, subsystems, major software functions, and data routing.

(3) A tabular listing of each time delay source and its individual mean and plus and minus three-sigma contribution to the overall time delay. All time delay values shall be provided in milliseconds.

(4) The mean delay time and the plus and minus three-sigma values of the delay time relative to the mean value.

§ 417.225 Flight hazard areas analysis.

(a) *General.* A launch operator shall perform a flight hazard areas analysis to determine the regions of land, sea, and air (hazard areas) exposed to the potential adverse effects of planned and unplanned launch vehicle flight events and that must be monitored, controlled, or evacuated in order to ensure public safety. The flight hazard area requirements of this section apply to orbital and ballistic launch vehicles that use a flight termination system to protect the public. Flight hazard area requirements that apply to launch of an unguided suborbital rocket that use a wind weighting safety system are contained in § 417.235. A launch operator's flight hazard areas analysis for an orbital launch must satisfy the following:

(1) A launch operator shall use the methodologies for determining hazard areas for orbital launch provided in appendix A of this part. In addition, for both orbital and suborbital launch, a launch operator shall use the methodologies of paragraphs C417.5(f)–(i) of appendix C of this part for determining ship and aircraft hazard

areas for planned debris impacts. A launch operator shall use the methodologies for determining hazard areas provided in appendixes A and C of this part unless the launch operator demonstrates, clearly and convincingly, through the licensing process that another methodology achieves an equivalent level of safety.

(2) A launch operator's analysis must account for all adverse effects and hazards from planned and unplanned launch vehicle flight events, including impacts of inert components, blast effects due to explosive debris impact, projected debris due to debris impact, release of any toxic substance from normal propellant combustion, vehicle breakup or impacting debris, and any other hazard due to planned or unplanned launch vehicle events that may be unique to a launch.

(3) A flight hazard areas analysis must account for debris resulting from planned flight and potential launch vehicle failure determined according to the debris analysis of § 417.209. A launch operator shall determine the debris impact points and dispersions in accordance with the following:

(i) A flight hazard areas analysis must account for drag corrected impact points and dispersions for each class of impacting debris as a function of trajectory time.

(ii) The dispersion for each debris class must account for the position and velocity state vector dispersions at breakup, the delta velocities incurred from breakup produced by either aerodynamic forces or explosive forces from flight termination system activation, the variance produced by winds, variance in ballistic coefficient for each debris class, and any other dispersion variances.

(iii) A launch operator's flight hazard areas analysis may account for the survivability of debris fragments that are subject to reentry aerodynamic forces or heating. A debris class may be eliminated from the analysis if the launch operator performs a survivability analysis and demonstrates that the debris will not survive to impact.

(4) A launch operator's analysis must account for launch vehicle trajectory dispersion effects in the surface impact domain. The analysis must account for trajectory variations, including plus and minus three-sigma variations in the jettison time for each intentionally jettisoned launch vehicle component.

(5) A launch operator's analysis must define the ship and aircraft hazard areas for which Notices to Mariners (NOTMAR) and Notices to Airman (NOTAM) must be issued and the areas where the launch operator must survey

in accordance with § 417.121(f). The results of a launch operator's flight hazard areas analyses shall be used to establish launch safety rules in accordance with § 417.113.

(b) *Flight hazard area.* For each launch, a launch operator shall establish an overall flight hazard area as an area surrounding the launch point that encompasses all hazard areas and safety clear zones established in accordance with paragraphs (d) through (h) of this section. Figure 417.225–1 illustrates a flight hazard area for a coastal launch site. Figure 417.225–2 illustrates a flight hazard area for a land locked launch site. A flight hazard area must account for planned launch vehicle events and potential launch vehicle failures, including any potential commanded flight termination. A flight hazard area must be contained inside the flight control lines established in accordance with § 417.211.

(c) *Flight corridor.* For regions outside the flight hazard area, a launch operator shall define a flight corridor, which extends downrange from a flight hazard area as illustrated by figure 417.225–3. A flight corridor must be bounded by the flight control lines established in accordance with § 417.211, and must include any land overflight permitted by a gate established in accordance with § 417.219. Any land overflight area must be bounded by a five-sigma cross range trajectory dispersion about the nominal launch vehicle trajectory. A flight corridor must extend for all downrange positions from the flight hazard area to the no longer endanger time determined in accordance with § 417.221(c).

(d) *Debris impact hazard area.* A launch operator shall determine a debris impact hazard area that accounts for the impact of debris resulting from a commanded flight termination or spontaneous breakup due to a launch vehicle failure and accounts for individual impact locations for each non-inert debris fragment, including explosive or toxic debris. A launch operator shall ensure that a debris hazard area is contained within the flight hazard area and is derived in accordance with the following:

(1) Except as permitted by paragraph (d)(2) of this section, a debris hazard area must be bounded by an individual casualty contour that defines where the individual casualty probability (P_C) criteria of 1×10^{-6} required by § 417.107(b) would be exceeded if one person were assumed to be in the open and inside the contour during launch vehicle flight. A launch operator shall determine an individual casualty contour in accordance with the following:

(i) The determination of an individual casualty contour must be an iterative process of evaluating person location points in the uprange and downrange directions and both crossrange directions. A launch operator shall use the methodology contained in A417.7 of appendix A of this part unless the launch operator demonstrates, clearly and convincingly, through the licensing process that another methodology achieves an equivalent level of safety.

(ii) For each uprange or downrange distance along the nominal instantaneous impact point trace, individual person location points shall be investigated at progressively increasing crossrange distances until one is found that produces an individual casualty probability of less than the 1×10^{-6} criteria.

(iii) As impact points being investigated progress downrange or uprange, the individual casualty contour will come to a close at a point where the individual casualty criteria can no longer be exceeded for any person located further downrange or uprange on the nominal instantaneous impact point trace.

(2) Rather than calculating an individual casualty contour uprange of the launch point as required by paragraph (d)(1) of this section, a launch operator may elect to define the uprange debris impact hazard area as an area surrounding the launch point with a radius equal to the greatest inert debris impact radius and any additional radius due to non-inert debris.

(3) The input for determining a debris impact hazard area must include the results of the trajectory analysis required by § 417.205, the malfunction turn analysis required by § 417.207, the wind analysis required by § 417.217, and the debris analysis required by § 417.209 to define the impact locations of each class of debris established by the debris analysis.

(4) A debris impact hazard area must account for the greatest potential debris impact dispersion. The analysis must assume that the launch vehicle flies until it exceeds a flight safety limit associated with the greatest potential debris impact displacement. The analysis must also assume trajectory conditions that maximize a change in debris impact distance during the flight safety system delay time determined in accordance with § 417.223 and use a debris model that is representative of a flight termination or aerodynamic breakup, whichever results in the greatest debris dispersion. For each launch vehicle breakup event, the analysis must account for trajectory and breakup dispersions, variations in

debris class characteristics, and debris dispersion due to wind.

(5) A debris impact hazard area must account for each impacting debris fragment classified in accordance with § 417.209(c). A debris impact hazard area need not account for debris with a ballistic coefficient of less than three.

(6) The analysis must account for classes of debris and the maximum number of debris fragments within a debris class in accordance with § 417.209(c). Debris classes shall be defined for potential launch vehicle failures that may result in launch vehicle breakup in the flight hazard area.

(7) The analysis must account for the probability of occurrence of each type of launch vehicle failure. The analysis must account for vehicle failure probabilities that vary depending on the time of flight. The analysis must also account for the type of vehicle breakup, either by the flight termination system or by aerodynamic forces that may result in a different probability of existence for each debris class.

(8) The analysis must account for the debris classes produced by a launch vehicle failure or a commanded flight termination and the resulting three-sigma debris impact dispersions. The impact point and the three-sigma debris impact dispersions shall be determined for each debris class at each failure time.

(9) In addition to failure debris, the analysis must account for nominal jettisoned body debris impacts and the corresponding three-sigma debris impact dispersions. The analysis must account for the planned number of debris fragments produced by normal separation events during flight with a probability of occurrence equal to the launch vehicle success rate at the time of each separation event.

(e) *Blast overpressure hazard area.* A launch operator shall define a blast overpressure hazard area as a circle extending from an explosive debris impact point with a radius equal to the 3.0-psi overpressure distance produced by the equivalent TNT weight of the explosive debris. The analysis must account for the maximum possible total solid and liquid propellant load capability of the launch vehicle and any payload at debris impact. A launch operator shall compute the overpressure radius using the TNT equivalency equation used for quantity distance computations and in accordance with the methodology provided in appendix A of this part. A launch operator shall add the overpressure radius to each explosive debris impact to define the overall blast overpressure hazard area.

(f) *Other hazards.* A launch operator shall identify any additional hazards, such as radioactive material, that may exist on the launch vehicle or payload that in the form of debris may be an additional hazard to the public. For each such hazard, the launch operator shall identify a hazard area that encompasses any debris impact point and its dispersion and includes an additional hazard radius that accounts for the additional hazard. A launch operator shall account for any hazards due to toxic release and distant focus overpressure blast in accordance with § 417.229 and § 417.231, respectively.

(g) *Flight hazard area ship-hit contours.* Where applicable, a launch operator shall perform an analysis to define ship hazard areas, referred to as ship-hit contours, to ensure that the probability of hitting a ship satisfies the collective probability threshold of 1×10^{-5} required by § 417.107(b). The flight hazard area shall encompass all ship-hit contours. A launch operator shall determine ship-hit contours in accordance with the following:

(1) A launch operator shall determine ship-hit contours for one to 10 ships in increments of one ship. For each given number of ships, the associated ship-hit contour must bound an area around the nominal instantaneous impact point trace where, if the given number of ships were located on the contour, the collective probability of impacting any ship would be less than or equal to the 1×10^{-5} ship-hit criteria. A launch operator shall determine each ship hit contour in accordance with the following:

(i) The determination of a ship-hit contour for a given number ships must be an iterative process of evaluating ship location points that have increasing downrange and crossrange distances from the launch point. The total surface area for the given number of ships shall be centered at each ship location point evaluated. A launch operator shall use the methodology for computing ship-hit probability and generating the ship-hit contours contained in A417.5 of appendix A of this part unless the launch operator demonstrates, clearly and convincingly, through the licensing process that another methodology achieves an equivalent level of safety.

(ii) For each downrange distance along the nominal instantaneous impact point trace, ship location points with progressively increasing crossrange distance shall be evaluated until a ship location point is reached that corresponds to a ship-hit probability that is less than or equal to 1×10^{-5}.

(iii) As the ship location points being evaluated progress downrange, each

ship-hit contour will come to a close on the nominal instantaneous impact point trace at a point where the ship-hit criteria can no longer be exceeded for any point further downrange for the number of ships for which the contour is being generated.

(2) The analysis must account for all classes of debris and the number of debris fragments within a debris class as determined in accordance with § 417.209(c). A ship-hit contour need not account for debris with a ballistic coefficient of less than three.

(3) A launch operator shall account for debris classes in accordance with § 417.209(c) for both nominal staging events and potential vehicle failures that may result in vehicle breakup in the flight hazard area. Vehicle failures shall be analyzed as a function of probability of occurrence. As applicable, debris classes shall be produced for both flight termination and for aerodynamic breakup and modeled as a function of probability of occurrence.

(4) Each debris class shall describe the mean impact point and the three-sigma debris impact dispersions. The analysis must account for launch vehicle failure probabilities as a function of flight time. The analysis must also account for the type of vehicle breakup, either by the flight termination system or by aerodynamic forces that may result in a different probability of occurrence for each debris class.

(5) A launch operator shall determine the need to survey the ship-hit contours during the launch vehicle countdown procedures in accordance with A417.5(c) of appendix A. When surveillance is required, a launch operator shall survey for ships in accordance with § 417.121(f). A launch operator shall implement launch safety rules in accordance with § 417.113 where flight shall not be initiated if, at the time of flight, the number of ships within any ship-hit contour is greater than or equal to the number of ships for which the contour was generated.

(6) A launch operator shall use the ship-hit contour for 10 ships as a ship hazard area for providing notice to mariners in accordance with § 417.121(e).

(h) *Flight hazard area aircraft-hit contour.* A launch operator shall determine an aircraft-hit contour to ensure that the probability of hitting an aircraft satisfies the individual probability threshold of 1×10^{-8} required by § 417.107(b) for the flight hazard area around the launch point. A launch operator shall ensure that the aircraft-hit contour is contained within the flight hazard area and is enforced for altitudes extending from zero to 60,000

feet. A launch operator shall determine an aircraft-hit contour in accordance with the following:

(1) A launch operator shall determine an aircraft-hit contour that bounds an area around the nominal instantaneous impact point trace where, if an aircraft were located on the contour, the individual probability of impacting the aircraft would be less than or equal to the 1×10^{-8} aircraft-hit criteria. A launch operator shall determine an aircraft-hit contour following the same method used to determine ship-hit contours required by appendix A of this part.

(2) A launch operator shall use the dimension of the largest aircraft operated in the vicinity of the launch or, if unknown, the dimensions of a Boeing 747 aircraft.

(3) The analysis must account for all classes of debris and the number of debris fragments within a debris class as determined in accordance with § 417.209(c). An aircraft-hit contour need not account for debris with kinetic energy of less than 11 foot pounds.

(4) The analysis must account for debris classes in accordance with § 417.209(c) for both nominal staging events and potential vehicle failures that may result in vehicle breakup in the flight hazard area. Vehicle failures shall be analyzed as a function of probability of occurrence. Debris classes shall be produced for both flight termination and for aerodynamic breakup and modeled as a function of probability of occurrence.

(5) Each debris class must describe the mean impact point and the three-sigma debris impact dispersions. The analysis must account for launch vehicle failure probabilities as a function of flight time. The analysis must also account for the type of vehicle breakup, either by the flight termination system or by aerodynamic forces that may result in a different probability of occurrence for each debris class.

(i) *Flight corridor ship hazard areas.* Within a flight corridor outside the flight hazard area, a launch operator shall establish a ship hazard area for each planned debris impact for the issuance of notice to mariners in accordance with § 417.121(e). The ship hazard area must consist of an area centered on the planned impact point and defined by the larger of the three-sigma impact dispersion ellipse or an ellipse with the same semi-major and semi-minor axis ratio as the impact dispersion, where, if a ship were located on the boundary of the ellipse, the probability of hitting the ship would be less than or equal to 1×10^{-5}. A launch operator shall determine ship hazard areas for planned debris impacts using the methodologies contained in paragraphs C417.5(h) and C417.5(i) of appendix C, which apply to both orbital and suborbital launch unless the launch operator demonstrates, clearly and convincingly, through the licensing process that another methodology achieves an equivalent level of safety. A launch operator shall determine if surveillance of a ship hazard area is required in accordance with paragraph C417.5(g) of appendix C of this part.

(j) *Flight corridor aircraft hazard areas.* Within a flight corridor outside the flight hazard area, a launch operator shall establish aircraft hazard areas for each planned debris impact for the issuance of notices to airmen in accordance with § 417.121(e). Each aircraft hazard area must encompass an air space region, from an altitude of 60,000 feet to impact on the Earth's surface, that contains the larger of the three-sigma drag impact dispersion or an ellipse with the same semi-major and semi-minor axis ratio as the impact dispersion, where, if an aircraft were located on the boundary of the ellipse the probability of hitting the aircraft would be less than or equal to 1×10^{-8}. A launch operator shall determine aircraft hazard areas for planned debris

impacts for both orbital and suborbital launch using the methodology contained in paragraph C417.5(f) of appendix C of this part.

(k) *Flight hazard area analysis products.* The products of a launch operator's flight hazard area analysis to be submitted in accordance with § 417.203(c) must include, but need not be limited to, the following:

(1) A chart that depicts the flight hazard area, including its size and location.

(2) A chart that depicts each hazard area required by this section.

(3) A description of each hazard for which analysis was performed; the methodology used to compute each hazard area; and the debris classes for aerodynamic breakup of the launch vehicle and for flight termination. For each debris class, the launch operator shall define the number of debris fragments, the variation in ballistic coefficient, and the standard deviation of the debris dispersion.

(4) Charts that depict the ship-hit contours, the individual casualty contour, and the aircraft-hit contour.

(5) Charts and a description of the flight corridor, including any regions of land overflight.

(6) A description of the aircraft hazard area for each planned debris impact inside the flight corridor, the information to be published in a Notice to Airmen, and all information required as part of any agreement with the FAA ATC office having jurisdiction over the airspace through which flight will take place.

(7) A description of any ship hazard area for each planned debris impact inside the flight corridor and all information required in a Notice to Mariners.

(8) A description of the methodology used for determining each hazard area.

(9) A description of the hazard area operational controls and procedures to be implemented for flight.
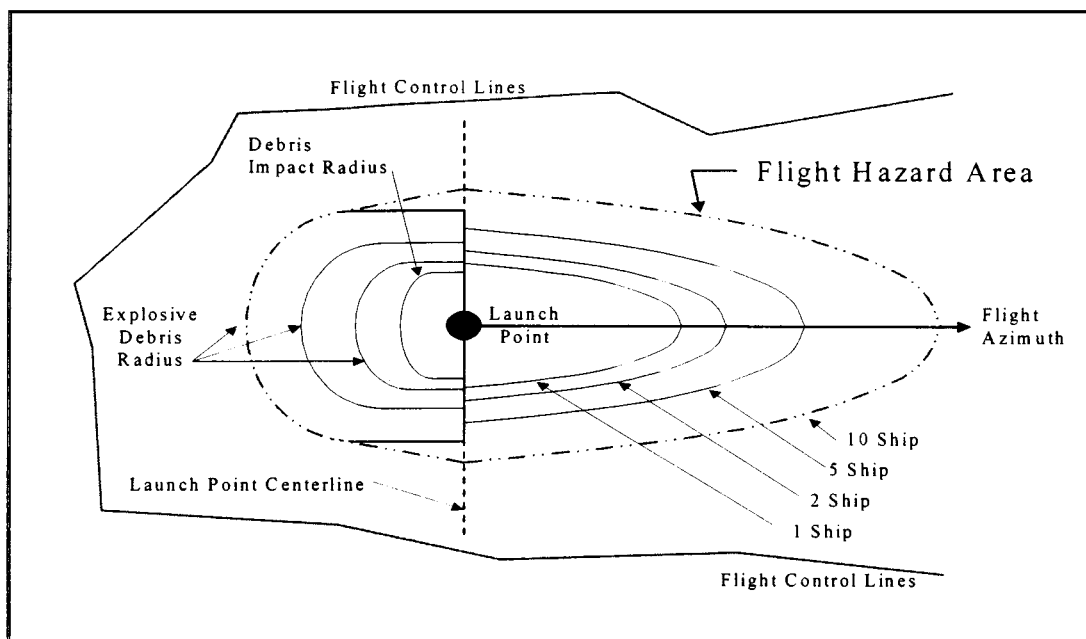
Figure 417.225- 1, Illustration of a Flight Hazard Area for a Coastal Launch Site
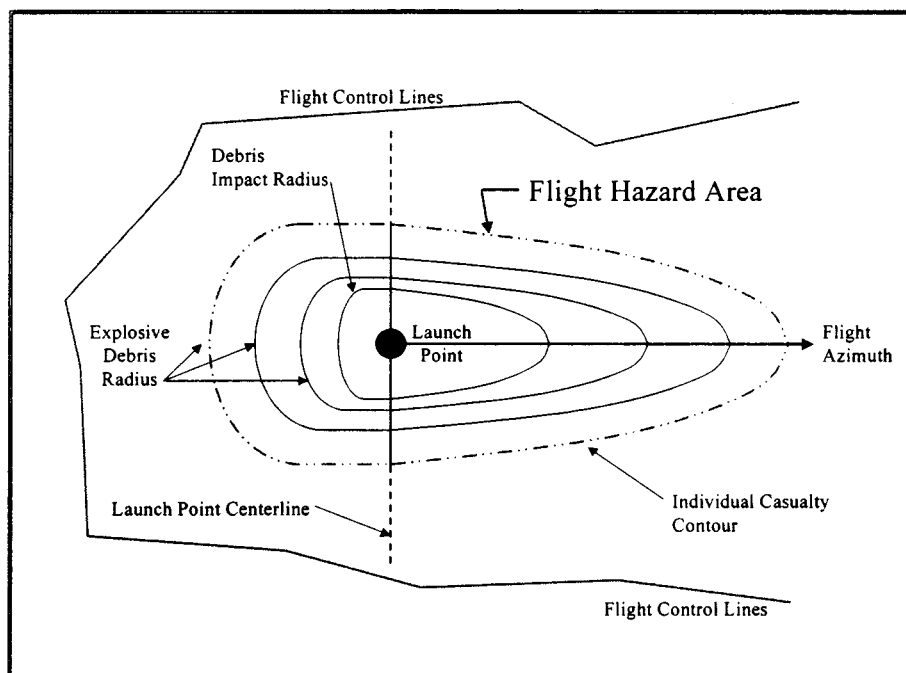

Figure 417.225- 2, Illustration of a Flight Hazard Area for a Land Locked Launch Site
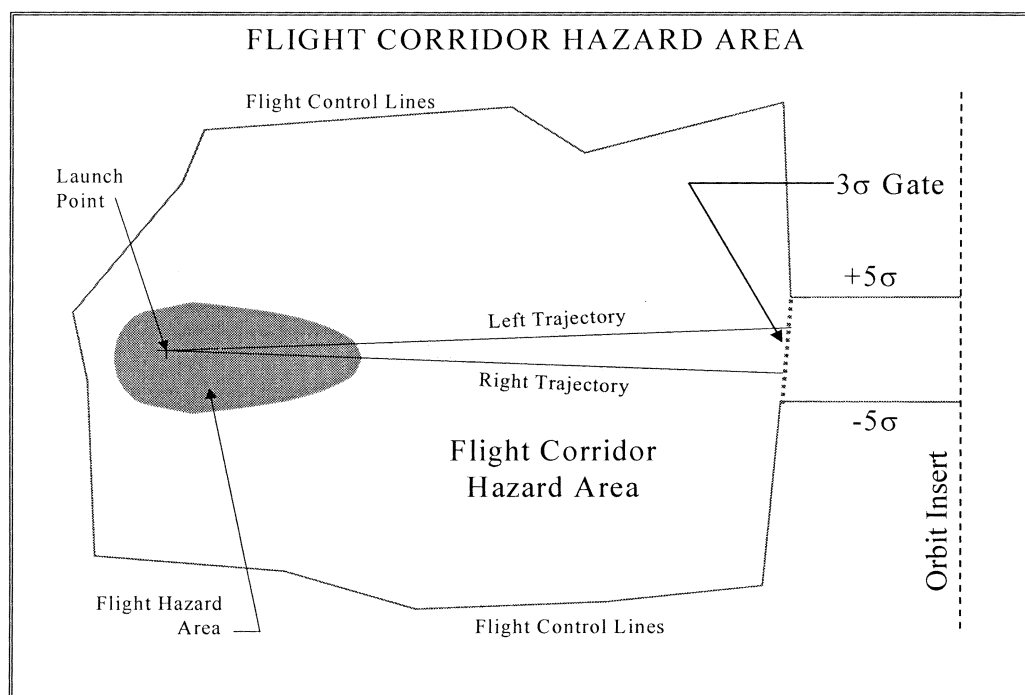
FLIGHT CORRIDOR HAZARD AREA

Flight Control Lines

Launch
Point

3σ Gate

+5σ

Left Trajectory

Right Trajectory

-5σ

Flight Corridor
Hazard Area

Orbit Insert

Flight Hazard
Area

Flight Control Lines

Figure 417.225- 3, Illustration of a Flight Corridor Hazard Area

§ 417.227   Debris risk analysis.

(a) *General.* A launch operator shall perform a debris risk analysis to determine the expected average number of casualties (E_C) to the collective members of the public exposed to inert and explosive debris hazards from the proposed flight of a launch vehicle. The results of the debris risk analysis must be included in the launch operator's demonstration of compliance with the public risk criteria required by § 417.107 (b). A launch operator's debris risk analysis must include an evaluation of risk to populations on land, including regions of launch vehicle flight following passage through any gate in a flight safety limit boundary established in accordance with § 417.219. The debris risk analysis requirements of this section apply to all launches.

(b) *Debris risk analysis constraints.* A launch operator's debris risk analysis must be performed in accordance with the following:

(1) A launch operator shall use the methodologies and equations provided in appendix B of this part when performing a debris risk analysis unless, through the licensing process, the launch operator provides a clear and convincing demonstration that an alternate method provides an equivalent level of safety.

(2) A launch operator's debris risk analysis must account for the following populations:

(i) The overflight of populations located outside a flight hazard area and inside any flight control lines established in accordance with § 417.211.

(ii) All populations located within five-sigma left and right crossrange of a nominal trajectory instantaneous impact point ground trace and within five-sigma of each planned nominal debris impact.

(iii) Any planned overflight of the public within any gate overflight areas established in accordance with § 417.219.

(iv) Any populations outside the flight control lines identified in accordance with paragraph (b)(10) of this section.

(3) [Reserved]

(4) A debris risk analysis must account for both inert and explosive debris hazards produced from any impacting debris caused by planned launch vehicle events and breakup of a launch vehicle due to activation of a flight termination system or spontaneous breakup due to a launch vehicle failure during launch vehicle flight. The analysis must account for the debris classes determined by the debris analysis required by § 417.209. A debris risk analysis need not account for debris with a ballistic coefficient of less than three. The analysis must account for all debris hazards as a function of flight time.

(5) A debris risk analysis must account for debris impact points and

dispersion for each class of debris in accordance with the following:

(i) A debris risk analysis must account for drag corrected impact points and dispersions for each class of impacting debris resulting from planned flight events and from launch vehicle failure as a function of trajectory time.

(ii) The dispersion for each debris class must account for the position and velocity state vector dispersions at breakup, the delta velocities incurred from breakup produced by either aerodynamic forces or explosive forces from flight termination system activation, the variance produced by winds, variance in ballistic coefficient for each debris class, and any other dispersion variances.

(iii) A launch operator's debris risk analysis may account for the survivability of debris fragments that are subject to reentry aerodynamic forces or heating. A debris class may be eliminated for the debris risk analysis if the launch operator performs a survivability analysis and demonstrates that the debris will not survive to impact.

(6) A debris risk analysis must account for launch vehicle failure probability. For the purposes of a debris risk analysis, a launch operator shall determine the launch vehicle failure probability from theoretical or actual launch vehicle flight data in accordance with the following:

(i) For a launch vehicle with fewer than 15 flights, a launch operator shall use an overall launch vehicle failure probability of 0.31.

(ii) For a launch vehicle with at least 15 flights, but fewer than 30 flights, a launch operator shall use an overall launch vehicle failure probability of 0.10 or the empirical failure probability, whichever is greater.

(iii) For a launch vehicle with 30 or more flights, a launch operator shall use the empirical failure probability determined from the actual flight history.

(iv) For a launch vehicle with a previously established failure probability that undergoes a modification to a stage, that could affect the reliability of that stage, the launch operator shall apply the previously established failure probability to all unmodified stages and the failure probability requirements of paragraphs (b)(6)(i) through (iii) of this section to the modified stage.

(7) A debris risk analysis must account for the dwell time of the instantaneous impact point ground trace over each populated or protected area being evaluated.

(8) A debris risk analysis must account for the three-sigma instantaneous impact point trajectory variations in left-crossrange, right-crossrange, uprange, and downrange as a function of trajectory time, due to launch vehicle performance variations as determined by the launch operator's trajectory analysis performed in accordance with § 417.205.

(9) A debris risk analysis must account for the effective casualty area as a function of launch vehicle flight time for all impacting debris generated from a catastrophic launch vehicle malfunction event or a planned impact event. A launch operator shall include both payload and vehicle systems and subsystems debris in the effective casualty area. The effective casualty area must account for bounce, skip, and splatter of inert debris, a 3.0-psi blast overpressure radius and projected debris effects for all potentially explosive debris, and a hazard radius for any other non-inert debris. The effective casualty area must account for all debris fragments determined as part of a launch operator's debris analysis in accordance with § 417.209.

(10) A debris risk analysis must account for current population density data obtained from a current population database for the region being evaluated or by estimating the current population using traditional population growth rate equations applied to the most current historical data available. A debris risk

analysis must account for the population density of population centers whose grid dimensions on Earth's surface do not exceed 1° latitude by 1° longitude. A debris risk analysis must account for any city with population equal to or greater than 25,000 as an individual population center.

(11) For a launch vehicle that uses a flight termination system, a debris risk analysis must account for the collective risk to any populations outside the flight control lines in the area surrounding the launch site during flight, including people who will be at any public launch viewing area during flight. A launch operator shall use the screening methodology provided in B417.7 of appendix B of this part to identify any populations for which the launch operator shall perform debris risk analysis. For such populations, in addition to the constraints listed in paragraphs (b)(1) through (b)(10) of this section, a launch operator's debris risk analysis must account for the following:

(i) The probability of a launch vehicle failure that would result in debris impact in the areas outside the flight control lines.

(ii) The failure rate of the launch operator's flight safety system. A launch operator may use a flight safety system failure rate of 0.002 if the flight safety system is in compliance with the flight safety system requirements of subpart D of this part. For an alternate flight safety system approved in accordance with § 417.107(a)(3), the launch operator shall demonstrate the validity of the probability of failure on a case-by-case basis through the licensing process.

(iii) Current population density data for the areas being evaluated that are outside the flight control lines. This data shall be determined based on the most current census data and projections for the day and time of flight.

(c) *Debris risk analysis products.* The products of a launch operator's debris risk analysis to be submitted in accordance with § 417.203(c) must include the following:

(1) A debris risk analysis report that provides the analysis input data, probabilistic risk determination methods, sample computations, and text or graphical charts that characterize the public risk to geographical areas for each launch.

(2) Geographic data showing the launch vehicle nominal, five-sigma left-crossrange and five-sigma right-crossrange instantaneous impact point ground traces; all exclusion zones relative to the instantaneous impact point ground traces; and populated

areas included in the debris risk analysis.

(3) A discussion of each launch vehicle failure scenario addressed in the analysis and the probability of occurrence, which may vary with flight time, for each failure scenario. This information must include a failure scenario where a launch vehicle flies within normal limits until some malfunction causes spontaneous breakup or results in a commanded flight termination. For a launch that employs a flight safety system, this information must also describe the most likely launch vehicle failure scenario and probability of occurrence for a random attitude failure as described in B417.7(e) of appendix B of this part.

(4) A population model applicable to the launch overflight regions that contains the following: area identification, location of the center of each population cell by geodetic latitude and longitude, total area, and number of persons in each population cell.

(5) A description of the launch vehicle, including general information concerning the nature and purpose of the launch and an overview of the launch vehicle, including a scaled diagram of the general arrangement and dimensions of the vehicle. A launch operator's debris risk analysis products may reference other documentation submitted to the FAA containing this information. The launch operator shall identify any changes in the launch vehicle description from that submitted during the licensing process according to § 415.109(e). The description must include:

(i) Weights and dimensions of each stage.

(ii) Weights and dimensions of any booster motors attached.

(iii) The types of fuel used in each stage and booster.

(iv) Weights and dimensions of all interstage adapters and skirts.

(v) Payload dimensions, materials, construction, any payload fuel; payload fairing construction, materials, and dimensions; and any non-inert components or materials that add to the effective casualty area of the debris, such as radioactive or toxic materials or high-pressure vessels.

(6) A typical sequence of events showing times of ignition, cutoff, burnout, and jettison of each stage, firing of any ullage rockets, and starting and ending times of coast periods and control modes.

(7) A launch operator shall submit the following information for each launch vehicle motor:

(i) Propellant type and ingredients.

(ii) Values of thrust.

(iii) Propellant weight and total motor weight versus time.

(iv) A description of each nozzle and steering mechanism.

(v) For solid rocket motors, internal pressure and average propellant thickness, or borehole radius, as a function of time.

(vi) Maximum impact point deviations as a function of failure time during destruct system delays. Burn rate as a function of ambient pressure.

(vii) A discussion of whether a commanded destruct could ignite a non-thrusting motor, and if so, under what conditions.

(8) A launch vehicle's launch and failure history, including a summary of past vehicle performance. For a new vehicle with little or no flight history, a launch operator shall provide summaries of similar vehicles. The data shall include the launches that have occurred; launch date, location, and direction; the number that performed normally; behavior and impact location of each abnormal experience; the time, altitude, and nature of each malfunction; and descriptions of corrective actions taken, including changes in vehicle design, flight termination, and guidance and control hardware and software.

(9) A discussion of the analysis performed for any populations outside the flight control lines in accordance with paragraph (b)(11) of this section.

(10) The value of E_C for each populated area evaluated.

§ 417.229   Toxic release hazard analysis.

For each launch, a launch operator shall perform a toxic release hazard analysis to determine any potential public hazards from any toxic release that will occur during the proposed flight of a launch vehicle or that would occur in the event of a flight mishap. A launch operator shall perform a toxic release hazard analysis using the methodologies contained in appendix I of this part. A launch operator shall use the results of the toxic release hazard analysis to establish for each launch, in accordance with § 417.113(b), flight commit criteria that protect the public from a casualty caused by any potential toxic release. The public includes any members of the public on land and any waterborne vessels and aircraft that are not operated in direct support of the launch.

§ 417.231   Distant focus overpressure explosion hazard analysis.

(a) *General.* A launch operator shall perform a distant focus overpressure blast effects hazard analysis to demonstrate that the potential public hazard resulting from impacting explosive debris will not cause windows to break with related injuries. A launch operator shall evaluate potential distant focus overpressure blast effects hazards in accordance with the requirements of this section, which require a launch operator to employ either the deterministic analysis requirements of paragraph (b) of this section or the probabilistic analysis requirements of paragraph (c) of this section.

(b) *Deterministic distant focus overpressure hazard analysis.* Except as permitted by paragraph (c) of this section, a launch operator shall perform a deterministic distant focus overpressure hazard analysis in accordance with the following:

(1) *Explosive yield factors.* A launch operator's distant focus overpressure hazard analysis must identify the explosive yield factor curves for each type or class of solid or liquid propellant used by the launch vehicle. For a launch vehicle that uses class 1.3 solid propellant HTPB or PBAN, a launch operator shall perform a distant focus overpressure hazard analysis using the explosive yield factor curves provided in figures 417.231–1 and 417.231–2 unless the launch operator demonstrates, clearly and convincingly, through the licensing process that other explosive yield factor curves apply to the launch and provide for an equivalent level of safety.

(2) *Determine the maximum credible explosive yield.* A launch operator shall determine the maximum credible explosive yield resulting from the impact of explosive debris resulting from potential launch vehicle failures and flight termination as determined by the debris analysis of § 417.209. The explosive yield shall be determined as a function of impact mass and velocity of impact on the Earth's surface. A launch operator shall determine the explosive yield, expressed as a TNT equivalent, using the explosive yield factor curves determined in accordance with paragraph (b)(1) of this section. This shall be accomplished for impacts of HTPB or PBAN in accordance with the following:

(i) *Impacts of intact motors or motor segments on soil.* For an intact impact of a HTPB or PBAN solid propellant motor or motor segment, a launch operator shall use the explosive yield factor curves in figure 417.231–1 to determine the explosive yield, expressed as a TNT equivalent. For impact speeds of less than 100 feet per second, the launch operator shall assume the results to be zero. For impact speeds exceeding 800 feet per second, the launch operator shall use the results produced by a speed of 800 feet per second. For a motor or motor segment with a diameter smaller than 40 inches, the launch operator shall use the yield factor for a diameter of 40 inches. For a motor or motor segment with a diameter larger than 146 inches, the launch operator shall use the yield factor for a diameter of 146 inches. For a motor or motor segment with a diameter between 40 and 146 inches, not otherwise specifically represented in Figure 417.231–1, the launch operator shall obtain the yield factor by linear interpolation between the curves represented in Figure 417.231–1.

(ii) *Impacts of propellant on soil.* For an impact of a HTPB or PBAN solid propellant chunk, a launch operator shall use the explosive yield factor curves in figure 417.231–2 to determine the explosive yield, expressed as a TNT equivalent. For impact speeds less than 100 feet per second, the launch operator shall assume the results to be zero. For impact speeds exceeding 800 feet per second, the launch operator shall use the results produced by a speed of 800 feet per second. For a propellant chunk smaller that 300 pounds, the launch operator shall use the yield factor of a 300-pound propellant chunk. For propellant chunk larger than 60,000 pounds, the launch operator shall use the yield factor of a 60,000-pound propellant chunk. For a propellant chunk between 300 and 60,000 pounds, not otherwise specifically represented in figure 417.231–2, the launch operator shall obtain the yield factor by linear interpolation between the curves represented in figure 417.231–2.
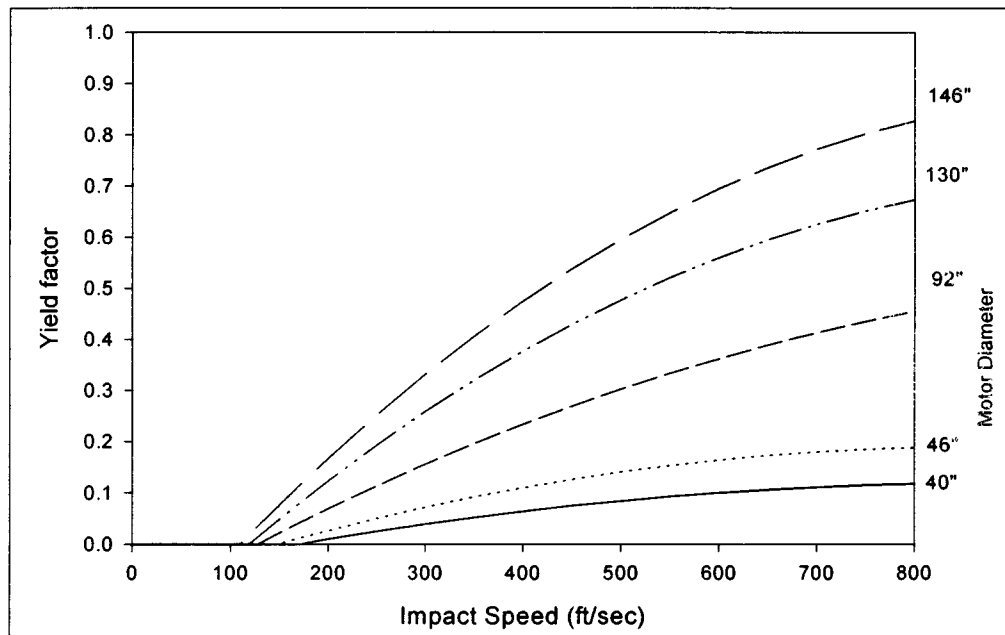
Figure 417.231-1. Motor Side-On Impact on Soil
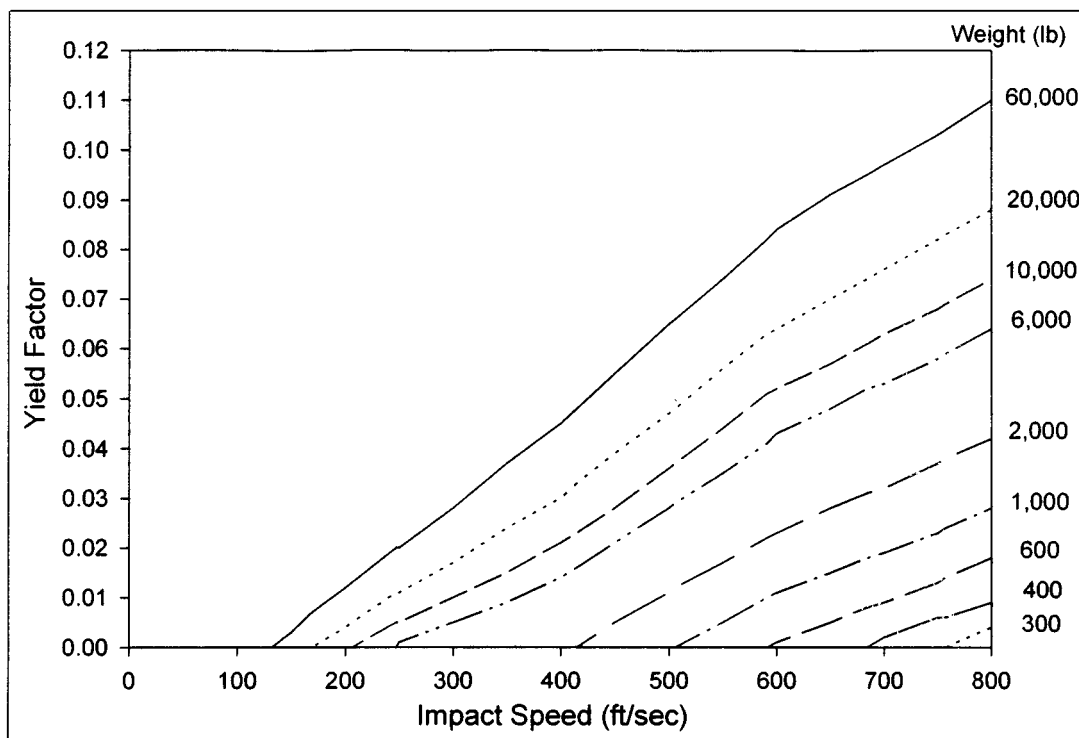

Figure 417.231-2. Chunk Impact on Soil

(3) *Characterize the population exposed to the hazard.* A launch operator shall determine if any population centers are vulnerable to a distant focus overpressure hazard using the methodology provided by section 6.3.2.4 of the American National Standard Institute's ANSI S2.20–1983, "Estimating Air Blast Characteristics for Single Point Explosions in Air with a Guide to Evaluation of Atmospheric Propagation and Effects." The launch operator shall perform these calculations in accordance with the following:

(i) For the purposes of this analysis, a population center is defined as any area outside the launch site and not